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Proceedings O-P-13

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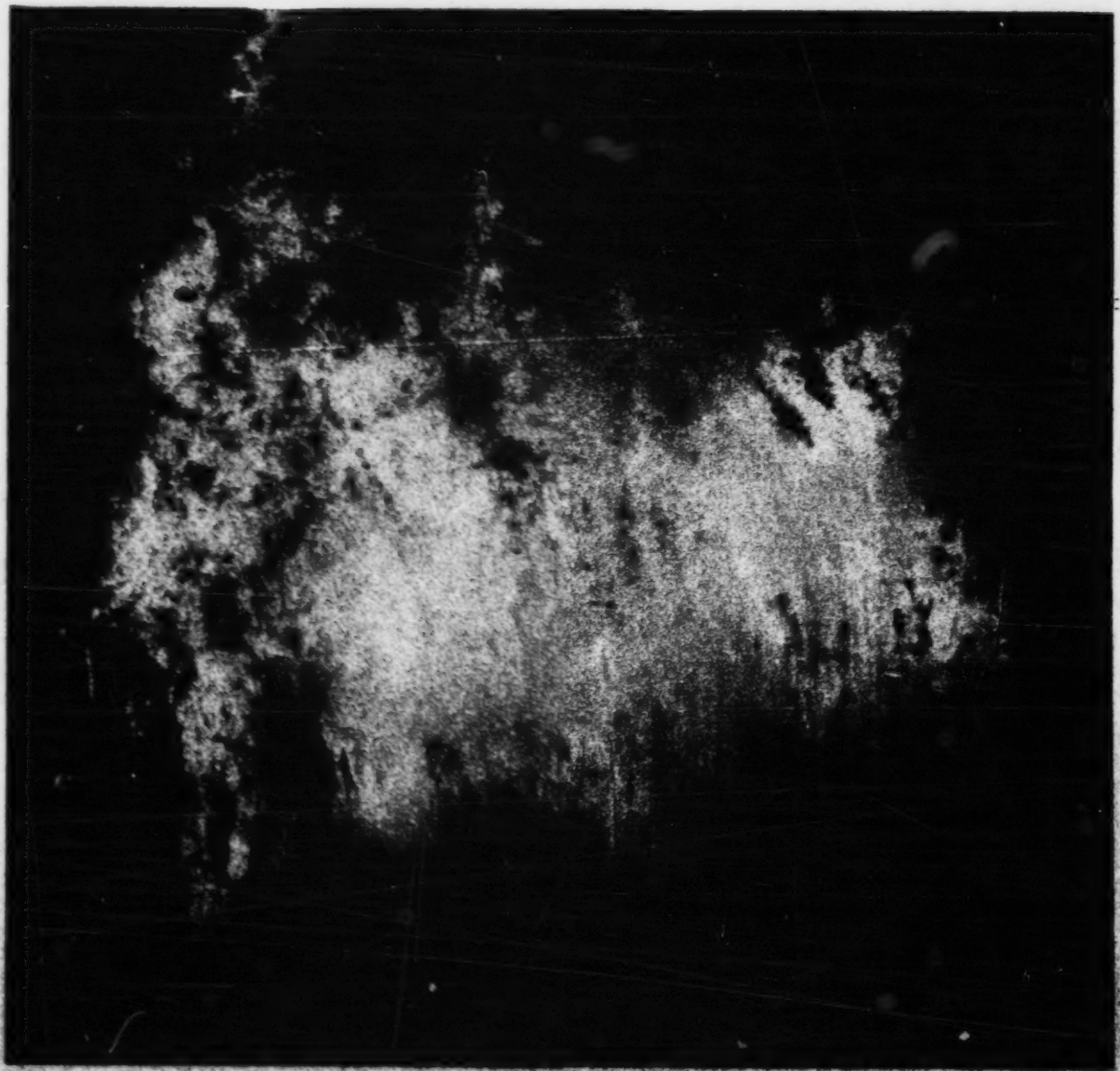
Ministry of Natural Resources

Forest Fire Management Symposium



Proceedings of a Symposium sponsored by the Ontario Ministry of Natural Resources and the Great Lakes Forest Research Centre under the auspices of the Canada-Ontario Joint Forestry Research Committee

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FOREST FIRE MANAGEMENT SYMPOSIUM

Proceedings of a Symposium sponsored by the
Ontario Ministry of Natural Resources
and the
Great Lakes Forest Research Centre
under the auspices of the
Canada-Ontario Joint Forestry Research Committee
Sault Ste. Marie, Ontario
15-18 September, 1984

B.J. STOCKS, R.G. ELLIOTT and J.D. WALKER, COCHAIRMEN

GREAT LAKES FOREST RESEARCH CENTRE

CANADIAN FORESTRY SERVICE

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FOREWORD

A Symposium on Forest Fire Management cosponsored by the Ontario Ministry of Natural Resources (OMNR) and the Great Lakes Forest Research Centre of the Canadian Forestry Service (CFS) was held from 15 to 18 October, 1984 in Sault Ste. Marie, Ontario. This was the 13th in a continuing series of annual symposia conducted under the auspices of the Canada-Ontario Joint Forestry Research Committee (COJFRC). These symposia provide a forum for discussions and interchange of ideas among provincial, industrial, academic and research foresters working in Ontario. Over 200 delegates attended this symposium, including a small number from other provinces (Alberta, Manitoba, Newfoundland) and three representatives from the United States Forest Service. Seventeen papers were presented.

The theme of this year's symposium, "Integrating fire and forest resource management in Ontario", stressed the importance of incorporating forest fire management into future management plans for the industrial and recreational use of the forest. The symposium consisted of two sessions. The first, entitled "Client comments and resource perspectives", ran for one day, while the second, entitled "Meeting the challenge", ran for a day and a half. During Session I papers outlining the impact of fire on wildlife, recreation, forest management, and wood supply were presented. Session II dealt with some of the research currently being conducted to answer questions raised by client groups in Session I. Invited speakers from OMNR, the CFS, forest industry, and the academic community participated.

A poster session ran concurrently with Sessions I and II, and time was set aside in the program to allow delegates to view poster displays. In all, 16 exhibits highlighting fire research activity at the Great Lakes Forest Research Centre, the Petawawa National Forestry Institute and the University of Toronto, as well as a number of OMNR projects, were presented.

This symposium presented the first opportunity for a large number of Ontario forest and fire managers to discuss the integration of fire management into overall forest resource planning. Symposium organizers are optimistic that the momentum generated on this occasion will continue, with more comprehensive resource planning being the result.

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Cover photo: Burnout operation on Ignace Fire No. 7 in northwestern Ontario, 30 May 1976.

OPENING REMARKS

J.R. Sloan[1]
Deputy Minister of Natural Resources
Ontario Ministry of Natural Resources
Toronto, Ontario

Ladies and gentlemen, I'd like to start off with a bang tonight. I'd like to clear the decks so we can all get down to business.

Forest fire fighting--especially on the scale on which it is practised here in Ontario --can be a hot topic, and no pun intended. When those huge clouds of smoke are billowing out of northern Ontario, we can spend millions of dollars in an awfully big hurry. We can also have a significant impact on local residents, our forest-based industry and the tourist industry.

In a fireflap, staff across the province --who are working hard to achieve important resource management targets--can suddenly be plucked from their jobs and be asked to join the fire organization to help out in emergencies. They can be away for weeks at a time--sometimes several times a year.

There's no doubt about it: resource programs get interrupted sometimes because of fires--that's simply the nature of the beast. But our other tasks don't simply go away during a fire emergency. Our own duties are always waiting for us when we get home.

During a fireflap, of course, provincial fire staff work for days on end without a break. When the fires are all out, and all the mopping up is over, they, too, have to come back and face small mountains of paperwork. These are facts of life.

My role here tonight is to set the tone for the next three days of meetings. I suggest that the proper tone is one of cooperation between professionals, of resource managers working together to solve mutual problems and discuss common concerns.

I consider my role here tonight to be something like that of the chorus in Greek tragedy. I'm not really one of the characters on stage, but I have a pretty good sense of the big picture.

And, as with the Greek chorus, it's my role to describe the big picture, to tell the audience what's going on. I get to explain the action of the plot--and I always get to have the last word.

So--without further delay--let's begin our little drama.

Everyone in this room is a resource manager in one way or another. But just look at the tremendous variety of disciplines that are represented here tonight. Many of you, of course, are professional foresters and forest technicians. But there are also professional biologists, academics, administrators and planners here tonight. There are fire managers and district managers and forest managers and fisheries, parks and wildlife managers.

I know that, as professionals, you are all highly dedicated and committed. You have studied and worked and gained a great deal of specialized knowledge about your respective fields. And that's as it should be. But you all know there's a potential problem in becoming a specialist. You can become so thoroughly an expert in a narrow field that you develop tunnel vision. To borrow an appropriate phrase: you can't see the forest for the trees.

And I think that's why meetings such as this one--meetings with a broad appeal and relatively wide interest within the resource community--are very important.

I notice on your program that you'll be having presentations on almost all aspects of resource management as they relate to fire. I think that's very healthy, because it's important for resource managers to have a general awareness of the big picture.

We have to talk and listen carefully to one another, and I think it's important that we understand each other's point of view. We can achieve that kind of communication only by

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establishing a dialogue. I came here tonight to contribute, to try to help that dialogue along. Perhaps the best way to do that is to talk about integrated resource management, because it has an important bearing on your discussions here. If you're committed to efficient management, I think you have to be interested in this philosophy.

Before I go any further, however, I must say that I'm a little concerned. As a long-time civil servant--some would say a bureaucrat--I guess I'm more sensitive than most to the buzz words and the jargon of government.

Sometimes it seems that integrated resource management is just a buzz word. That worries me--because buzz words turn people off. One hears so much jargon these days, that even important concepts start to lose their meaning. And when they lose their meaning, it's usually not too long before they simply fall out of fashion.

Tonight, therefore, my first order of business is to set the record straight about integrated resource management. Let me tell you what integrated resource management is *not*.

It's *not* simply jargon. And it's *not* simply the latest fashionable phrase--a phrase whose time has come, and whose time will go just as soon. Furthermore, integrated resource management is *not* a phrase that's devoid of meaning.

Simply put, integrated resource management is the left hand not only *knowing* what the right hand is doing, but helping the right hand do whatever has to be done. Of course, an important corollary of this kind of management is that the process is centripetal--it draws as many people as possible into the planning process.

Integrated resource management is nothing new. In one way or another, it's been around for years. It was being practised before the Ontario Ministry of Natural Resources (OMNR) was reorganized more than a decade ago. And it's being practised by many OMNR managers today. But today we're hearing more about it, because in Ontario we've intensified our efforts to put that philosophy into practice.

As you know, integrated resource management emerged as one of the most important principles of OMNR's recent land use planning exercise.

The guidelines that emerged are a bit like an operational blueprint for OMNR. When we use that blueprint, and when we build on it, we are guided by the philosophy of integrated resource management.

Of course, publishing a blueprint or a plan doesn't make everything else fall into place. The guidelines didn't instantly convert everyone to integration. They didn't set all the specific standards we need, or clearly define our approach to all resource issues. Nor did they cover the whole range of situations to which integration was to be applied. In fact, we're in the midst of that fine-tuning process right now.

Nevertheless, the philosophy of integration *is* working. In 1980, for example, Ontario began a new era in forest management with the Forest Management Agreements (FMAs) program--a program that has changed Ontario forestry.

As you all know, the industry has always been very efficient at harvesting timber--after all, that was its primary business. Under FMAs, for the first time, Ontario's forest companies are also assuming responsibility for creating new forests on the land they have harvested. These days, they're preparing forest sites, planting trees and tending them so that they will flourish.

As a result, more silvicultural activities are being undertaken today in Ontario than ever before. And there's another big payoff: industry is discovering new techniques and new equipment that are leading to greater efficiency of the entire operation. Nowadays, cutting trees and growing them are being recognized as part and parcel of the same process. These two aspects of forest management are being--dare I say it?--better integrated all the time.

And I would argue that this kind of integration springs directly from FMAs--the agreements that reflect OMNR's philosophy of integrated resource management.

At the same time, forest management is being integrated with the management of other resources across the province. Under the FMA program, for example, the public has several opportunities to influence the agreements and the operating plans created for them.

Interest groups as diverse as tourist outfitters and mineral prospectors are also having a say in the way forests are managed in Ontario.

I think this kind of dialogue is refreshing, positive and encouraging. There is an

ever-increasing number of mechanisms for reciprocation, too. These days, for example, foresters are also having an impact on the way minerals are managed and on the way the tourist industry is managed.

Of course, you'll always be able to find people who tell you that all is not sweetness and light in resource management. There will always be those willing to tell you that things are not perfect. But that's not a very profound observation.

What you won't find around the province are many people who disagree with the principle of integrating resource management. And that's because it just makes too much sense.

Now I've talked for a while in a general way about the integration of resource management. I don't think I've mentioned fire management even once. And that's because I've been saving that part for the last.

I think that one of the main reasons you've all come here for this symposium is that you're curious about fire management. More specifically, you're probably wondering what relation fire management has to your particular resource area. And I'm sure that those of you who do know may want to air some concerns and get more involved in fire decisions.

I know I don't have to convince those of you who are foresters that fire management has an important role to play in timber management but what about the rest of you? What about the biologists and the planners and the researchers in the audience tonight? What about the administrators and the academics?

Well, it seems to me that fire management is a very important aspect of the management of all resources. Fire managers are much more than glorified firemen.

In the old days, our strategy for managing fires was simple: to put all fires out. And, in normal situations, the strategy worked fairly well. But in particularly bad fire years, it simply couldn't work. What fire managers realized is something that other resource managers have also recognized recently. They recognized that they had to start managing fires in the context of protecting the whole spectrum of resource values.

Managing fire, they realized, also meant recognizing the values of wildlife and fisheries and recreation. It meant planning to protect these values, and understanding the impact of fire on them, too. That kind of multi-level protection meant that the values had to be identified carefully.

Once all the resource values in a given area have been identified, and once the potential impact of a forest fire has been worked out, fire managers can begin to set priorities. They can decide, for example, which areas should be protected from fire at all costs--areas in which there is a potential for loss of human life, for example. By the same token, they can also decide which areas may not require intensive protection from fire--areas in which there are no high-value resources, human habitation, or property.

Instead, fire managers and resource managers must first identify our high-value resource areas, assess the potential impact of fire on them, and develop an adequate protection plan for them. For other areas, fire managers have to develop a policy that can deal adequately with whatever situations may arise.

Over the longer term, the decisions fire managers make have a tremendous impact on the kinds of forests we'll have in the future. Their input is vital.

I think the approach to fire management I've just outlined is something relatively new, particularly as far as the public is concerned. The public perception of fire management is that it still involves a total fire suppression effort everywhere.

Therefore, I think that one of the biggest communication challenges facing fire managers is the need to explain what they do, and exactly why they do it.

These days, fire management involves much more than the suppression and prevention of fires. Properly speaking, it involves managing the impact of fire. Within the context of management, prevention and suppression become two different strategies for managing fire. Getting that kind of message across to the public and to other resource managers is very important.

We need to work on these strategic aspects of fire management. Take prevention, for example. We all know about Smokey the Bear, and we've all seen the roadside signs dealing with forest fire prevention. But what about fire prevention within the resource management organization itself? If a forest is about to be harvested, can the fire managers help determine the fire hazard posed by the slash? Can their input help determine whether there are natural boundaries or roads that would help lower the fire risk?

I think the answer to both these questions is "yes". What it boils down to is simply that we need to make sure that the potential impact of fire on all resources is very carefully analyzed. And that requires a great deal of communication.

As you may know, Ontario's fire management team has a lot of experience in communications. In fact, the Provincial Aviation and Fire Management Centre, located just down the road from here, has developed a worldwide reputation for excellence. And when I say worldwide, I mean just that. For example, I recently signed an agreement on behalf of OMNR to transfer technology to the People's Republic of China under the auspices of the Canadian International Development Agency.

Under the agreement, OMNR's fire managers will provide technical assistance for enhanced forest fire protection in Jiagedaqi Province in northeast China. They'll be setting up a model forest fire management system for that province. In effect, the agreement makes our fire managers the primary Canadian contractors for delivering this technical aid and expertise.

I would suggest that the reason our fire managers were selected is pretty straightforward: they are, very simply, among the best in the world. But our leadership wasn't created in a vacuum. There's a long history of cooperative fire management in Ontario, in Canada, and indeed throughout North America.

Through the United States Interagency Fire Center, in Boise, Idaho, firefighting equipment and technology have been available on loan for years.

Canada recently created a similar center in Winnipeg, through which the same kind of cooperative program is run. During the recent fireflap in northwestern Ontario, just before Labor Day, Ontario was able to borrow four CL-215 waterbombers from the province of Quebec through the Interagency Center.

We regularly take advantage of other, similar cooperative initiatives, and we've even created a few of our own. For example, we have made tremendous progress here in Ontario in training forest industry personnel in fire management.

Since our cooperative training program began in 1981, thousands of woodworkers have been trained as fire crew members. As well, hundreds of forest industry supervisors have been trained as initial attack fire bosses.

And let's not forget about our own staff in other areas. During bad fires, hundreds of people from all over the province are sometimes asked to drop everything and rush up north, or even out west, to help out.

In other words, Ontario has developed a backup network of firefighting personnel that can be called on to enhance fire protection during emergencies. This would not have been possible without tremendous cooperation from our staff, industry, other governments and international agencies.

I want you all to take away something with you after this symposium is over. I want you to have developed a better feeling for the tremendous importance of cooperation in what we do. The mere fact that you're all here suggests to me that you know how important it is to work together.

I hope that your meetings over the next three days are both stimulating and productive. I also hope that you will come up with some practical suggestions for improving the integration of fire management.

Listen to the speakers. Visit the displays. Test the ideas that are presented against what you already know. Above all, seek to gain some new insights and understanding.

If these goals are acomplished, I believe we'll be that much farther down the road to managing resources the way we want to. It's a long road, but I believe we've already made substantial progress along our way.

Just a few years ago, we were starting out on that road, but we were all driving in separate cars. Some of us were driving Corvettes. Others were driving Pintos. Still others were trying to get the car started.

We still have a long way to go, but now at least we're all on the same bus. We're not travelling alone any more. In my view, that's a much better way to travel, and it's the best way to reach our destination.

I want to wish you all well for the rest of this symposium.

SESSION I

CLIENT COMMENTS AND RESOURCE PERSPECTIVES

FIRE MANAGEMENT AND WILDLIFE POLICY

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and

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Abstract.--The occurrence or absence of wildfires, in conjunction with their frequency and intensity, profoundly influences wildlife abundance. The long-term absence of fire, and the resultant overmature forest, drastically reduce browse for moose and deer. Controlled burning simulates the effects of natural disturbances, and, if used appropriately on a relatively small scale, creates the interspersion of age classes that favor many wildlife species. We must balance the values to be protected from fire with the wildlife values to be derived from fire.

Résumé.--Les feux de friche (ou leur absence) ainsi que leur fréquence et leur intensité influent profondément sur l'abondance de la faune. Une longue période sans feu (et la surmaturité qui l'accompagne) réduit énormément l'abroutissement par l'orignal et le cerf. Le brûlage dirigé a les mêmes effets que les incendies naturels, et, s'il est utilisé à bon escient à une échelle relativement petite, il permet d'intercaler les classes d'âge au profit de beaucoup d'espèces fauniques. Il faut tenir compte à la fois des valeurs qu'il faut protéger du feu et des avantages que celui-ci procure à la faune.

Introduction

Fire means different things to different people. When it destroys standing timber, it destroys jobs and businesses. But fire is also used to remove slash, to reduce the risk of wildfires, and to create a seedbed for a new timber crop. When left alone, the natural vegetation cycle in northern Ontario makes use of the silvicultural agent of fire to create high-grade black spruce (*Picea mariana* [Mill.] B.S.P.) or white pine (*Pinus strobus* L.) stands. Such fires are viewed with concern only when they affect us personally. Since the economic and social benefits of forests are based on more than wood fiber, fire is timely or untimely to an observer, depending on his interests.

Because a large portion of the Ontario economy is based on forestry, the economic return of a given forest tract is an important measure of the value of the forest. The forest is more than trees, however, and it is for this reason that the Ontario Ministry of Natural Resources (OMNR) is committed to integrated resource management. Both fire and forests, and the circumstances under which they occur, can have a profound influence on the abundance of wildlife. We have been asked to tell you how fire control or fire-use practices contribute to, or perhaps inhibit, the achievement of wildlife policy. We will discuss the need for, and the fact of, forest disturbances, and our policy of contributing to Ontario's economic and social well-being through wildlife, and the ways in which fire control and fire use can aid in achieving that policy.

Forest Disturbances and Wildlife

Since forest resource management deals with living and growing resources, it is a tool that can be utilized in renewing those resources. All organisms must die, but the agents of cutting, windthrow, fire and insects can, at the same time that they kill trees, perpetuate a forest system through its necessary cycles, whether natural or modified by man.

It is the immediacy of destruction by fire that makes it appear worse than the gradual and natural deterioration of overmature stands. The pulp company sees its wood reserves reduced overnight in a fire. The woodlands division must plan immediately to cut elsewhere. Tourist outfitters are immediately affected. And in all ways, government is affected because its client groups are affected.

OMNR is committed to integrated resource management. The basic resource that supports and produces all other natural resources is the land. Management of the land determines the crops the land produces (i.e., plant cover and the fauna that depend on it) and it determines the yield of all the benefits flowing from these crops. Consequently, management of the land determines the potential harvest of both trees and animals.

Management decisions may be made about where, how, and when to cut, about the layout of cuts, about the use of herbicides, pesticides, and fire, about whether or not to control wildfires, and whether or not to use fire under controlled conditions. Such management decisions can have a profound influence on the potential tree and animal harvests and associated social and economic benefits.

Fire suppression can prolong the life of mature or overmature softwood and mixedwood stands, and hence maintain the immediate reserves of a forest company. It can also delay stand renewal, and that may be helpful in achieving a better regulated forest in the next rotation. Only a well regulated forest can supply a steady and reliable stream of benefits--of wood, recreational opportunities, wildlife and scenery, and of the wages and profits based on all of these. To opt for this stability means to forego the immediate economic advantages of liquidating the capital of standing timber, but I base my remarks on the premise that the long-term benefits of stability of supply outweigh the short-term economic benefits of liquidation.

In theory, natural fire is an indispensable agent and it has always played a role in maintaining the northern ecosystems that are our concern. In a practical sense, however, wildfires are too unreliable for our highly organized way of life. We feel the need to regulate it.

And we do regulate fire. Fire suppression is a big industry in Ontario. My wildlife-management colleagues often say that if we are to have more moose and deer range, we need more fires and less fire suppression, and there may be something in what they say. Large tracts of black spruce or jack pine (*Pinus banksiana* Lamb.) forests are not suitable for moose and deer, but burns provide the type of forest cover they require.

Whether a change in a forest stand is gradual as in the deterioration of an overmature stand, quicker as in a spruce budworm outbreak, or abrupt as in a fire or windstorm, it is followed by either an earlier successional stage suitable for moose, for example, or a younger stand of the same successional stage, suitable for deer. These disturbances always yield the same species that were present before the disturbance, except in severe and repeated burns that may destroy spruce seed trees. Even then the return to a spruce stand is not prevented, only delayed.

Wildlife Policy

The goal of OMNR is "to provide opportunities for outdoor recreational and resource development for the continuous social and economic benefit of the people of Ontario, and to administer, protect and conserve public lands and waters." The concept of integrated resource management aims to maximize the achievement of all the elements of this goal statement, and demonstrates that land is basic to the management of renewable resources.

Land management influences vegetation, and vegetation management determines how suitable the resulting habitat is. Hence, it is basic decisions on land and vegetation management that determine the degree to which wildlife policy can be achieved and to which jobs and income based on wildlife resources can contribute to the economy of Ontario.

Tourism, its related industries, and trapping are economically important, especially in the north. Moreover, while spending on wildlife has economic consequences in all sectors of the economy, the benefits are felt to a much greater extent in the northern parts of the province.

Spending on wildlife in 1979 resulted in $700 million of sales, $355 million of income,

and 14,000 jobs. There is no doubt that these figures could be doubled. If fire management can be used to help achieve this goal, we would do well to use it.

The objectives of the wildlife program will be achieved by protecting, maintaining, creating, or rebuilding habitats so that we can establish healthy, abundant and diverse wildlife populations. Because of the integral role that fire plays in northern forests, we cannot ignore it, and in fact should use it where it is effective and economical. OMNR fire staff are very knowledgeable about fire behavior, and have a great deal of expertise in fire suppression and fire use.

Fire for Wildlife

Since the abundance of wildlife depends on habitat, and since habitat can depend on the occurrence of fire, fire management is a key to wildlife abundance.

The effect of fires in ecosystems is either to set back succession or to rejuvenate stands. Fires can maintain marshes by avoiding their succession to bogs and, later, fens and forests. While this also prevents the long-term development of populations of trees, hares, and deer, it can help to maintain, in the short term, populations of beaver, muskrat, and waterfowl. Which animal species we favor will depend on whether we use fires or permit wildfires to occur. Gullion (1970) claimed that ruffed grouse thrive in subclimax forests of poplar (*Populus* spp.) and that forest fires that bring about poplar also bring about grouse.

Thus a fire management program that actively brings about poplar stands helps to achieve a wildlife target. Such reasoning is not enough. Because poplar stands are only a phase in a natural cycle and wildlife is only one of the many products of land management, an integrated management program that includes fire management should try to achieve a well regulated forest, presenting all age-classes of various stand types on the smallest possible land area for an even flow of benefits.

Wildlife numbers may sometimes appear to be independent of habitat quality, however. The numbers of ruffed grouse and snowshoe rabbits, for instance, fluctuate widely about every 10 years, apparently independently of habitat conditions. Managing for the best possible grouse habitat is still not a wasted effort, if it is an integral part of the management effort that produces a well regulated forest, for such management leads to an even flow of benefits from that forest, and a stable yield of these benefits, including both grouse and pulpwood.

In Scandinavia, fire is not important for moose; early suppression renders fire unimportant as an ecological factor. Yet there is abundant superior moose habitat, and moose are abundant. Not only is fire suppressed intensively there, but the forest is managed intensively, 1% of it being cut over annually. This results in that well regulated forest that I referred to before. The moose harvest is well regulated to encourage high numbers of moose, and the degree of management intensity is based on many factors other than the biological potential of a forest site.

Depending on the site, a burn results in the highest number of moose from 10 to 30 years after the fire, and then moose numbers decline quickly (Kellsall et al. 1977). Moose habitat is not permanent; moose thrive in the mosaic of stand age and space because of their high fecundity and their way of colonizing newly suitable areas (Geist 1971). Thus it is that logging and fire management programs, singly or in combination, profoundly influence the potential for moose abundance by affecting habitat. Forest and fire management programs can favor or discourage wildlife habitat.

A flight over any large burn in the boreal forest reveals an obvious mosaic related to variations in the terrain. The intensity of a fire can vary from total removal of the tree cover and of the litter layer to a flash fire through dry grass, to an absence of fire on downhill slopes and in wet pockets. The more intensive this mosaic, i.e., the smaller the patches and the more varied the ages of the stands, the richer the plant and animal life.

Ideally, a program of fire suppression becomes more and more a program of fire management, i.e., a set of decisions to allow wildfires to burn, to limit them, and to extinguish them, as well as to set fires on purpose--provided that these decisions are based not only on motives of saving standing timber, jobs, and human life, but also on motives of bringing about conditions through the use of fire that will increase the production of timber, recreation opportunities, wildlife, jobs, and economic benefits.

The use of fire, like the use of any other management technique, applies and combines many scientific principles. Because of the large number of variables and because of the judgment involved, the use of fire is an art, and its application requires cooperation. The wildlife manager and the silviculturist must define the desired result of a fire, and

the fire manager must achieve it by using fire.

Bendell (1974) detected no correlation between forest fires and the abundance of moose in "documented burns." He ascribed this to the interaction of a great many variables such as the local distribution of animals, uneven effects of fires, animal behavior, other intrinsic characteristics of the animal populations observed, and the effect of hunting and predation.

Geist (1971), however, called the moose a fire follower. That the moose deserves this reputation is because it has a high and variable birth rate, a high dispersal rate, and a fluctuating abundance, and its numbers are limited by food supply. Moose do use old burns.

Attractive habitat in burns draws moose. If readily accessible to hunters in that habitat, these moose can be subject to high hunting pressure, even to the point that their rate of reproduction is lower than the optimum that the habitat can support. Thus the response of animal numbers to documented burns is of itself not significant: abundance of game animals depends on factors other than the suitability of their habitat.

We require land management that produces habitat suitable for moose production. Whether it is through logging, windthrow, insect damage, scarifying, herbicide spraying, or fire, we can effect changes in the vegetation, changes that can be tailored to the needs of wildfire. If public opinion tolerates it, fire can be used in the boreal forest to achieve both timber and wildlife objectives by creating conditions suitable for the renewal of both.

The usefulness of fire in tolerant hardwoods is severely restricted. A wildlife management technique used frequently in tolerant hardwoods in the past 25 years is the felling of cull maple (*Acer* spp.), birch (*Betula* spp.) and ash (*Fraxinus* spp.) trees to induce basal sprouting. Deer need such sprouts for food near the coniferous cover they require in winter.

To be useful, a fire must kill enough large trees to produce more browse from tree stumps than the fire will kill in browse-size seedlings. Flash fires in leaf litter are not hot enough to kill the larger trees. Effective fires require coniferous fuel to cause temperatures high enough at the base of the hardwoods to penetrate the insulating thick bark. There are very few cases in which these conditions coincide with the need to cause basal sprouting for deer browse. These few cases are further limited by the need for suitable weather and fuel conditions that make burning more difficult, so that the burn can be controlled more carefully. This is a challenge to the Algonquin regional staff.

Additional advantages of cutting in winter are improved access to deer yards and the immediate availability of winter browse from the crowns of freshly felled trees. In such cases, therefore, bulldozers and chainsaws are usually more effective than fire in the production of deer browse.

Summary

Wildlife in Ontario is adapted to fire, as is the boreal forest.

The best wildlife habitat is heterogeneous, and wildfires produce the variability which is the key to wildlife abundance. Management programs that affect wildlife habitat, including a planned fire management program, can improve that habitat significantly. In the technical sense that would mean a decision to bring about the conditions that favor wildlife. In the practical sense it may involve the need for public education, saying to those outside the profession that fire is useful, and telling our colleagues what kinds of results are needed and where they are needed.

The abundance of wildlife cannot be a direct measure of the effectiveness of fire, for wildfire abundance is an indirect effect, subject also to other forces. The use of fire will bring about only the habitat conditions that are necessary for wildlife abundance.

Literature Cited

Bendell, J.F. 1974. Effects of fire on birds and mammals. p. 73-125 *in* T.T. Kozlowski and C.E. Ahlgren, *Ed.* Fire and ecosystems. Academic Press, New York.

Geist, V. 1971. Mountain sheep--a study in behaviour and evolution. Univ. Chicago Press. 383 p.

Gullion, G.W. 1970. Factors affecting ruffed grouse populations in the boreal forests of northern Minnesota. p. 103-117 *in* Proc. 7th Internatl. Congr. Game Biol., Helsinki.

Kellsall, J.P., Telfer, E.S., and Wright, T.W. 1977. The effects of fire on the ecology of the boreal forest, with particular reference to the Canadian north: A review and selected bibliography. Dep. Environ., Can. Wildl. Serv., Ottawa, Ont. Occas. Pap. No. 32. 598 p.

FOREST FIRES: NATURE'S MANDATE FOR CHANGE

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Abstract.—Fire is portrayed as both a natural and an inescapable fact of life in North American forests and the adaptability of the forest environment to periodic fire is discussed. The effect of fire on wildlife habitat and patterns, and the role of fire in regulating biotic productivity and maintaining ecosystem diversity and stability, are outlined in detail.

Résumé. L'incendie est décrit comme le destin naturel et inéluctable des forêts de l'Amérique du Nord, et l'adaptabilité du milieu aux incendies périodiques fait l'objet d'une discussion. On précise l'action du feu sur l'habitat et la répartition faunique, le rôle régulateur qu'il exerce sur la productivité biologique et son effet sur la diversité et la stabilité des écosystèmes.

Introduction

For those who wish to conquer nature, forest fires are the ultimate challenge. Many images are created by intense anti-fire campaigns: terrifying, devastating walls of flame destroying all life, the ever-present Smokey the Bear glowering in the background. Pictures of young animals orphaned by this sinister force convince us that forest fires are the ultimate in natural disasters. The evidence seems overwhelming; thousands of hectares blackened, stark spires of dead trees, perhaps a raccoon family gazing towards its once-green home. Mother Nature in a vile frenzy has destroyed hundreds of years of forest growth. Destruction is complete and the forest will never be the same.

Popular images are often misleading and sometimes wrong. The image of forest fires as deadly destroyers without any redeeming virtue is at best misleading and at worst wrong. There is destruction of wood, true, but there is also creation—creation of seedbed for new forests and the opportunity for new shrubs and young forests to provide food and shelter for wildlife. When a forest burns, the loss of wood to the mill and the possibility of people losing jobs are difficult problems. For wildlife, however, the benefits of fires are numerous. In addition, the new seedbed created by the fire will renew the cycle of growth-death-regrowth upon which the forest is built.

Fire has always been an event in the natural world. Long before *Homo sapiens* evolved from his hominid ancestors, periodic fires were burning large areas in many different parts of the world. The Florida Everglades, for example, often considered an expansive watery marshland, have been subject to periodic fires for thousands of years. Towards the middle of the annual dry season, water levels often covered only the roots of an extensive growth of sawgrass. The heavy plant growth above water was dry and thick enough for lightning fires to cover many square kilometres. The water protected the roots and soil organic matter and no lasting damage was done. At the end of the dry season when plants and soil are very vulnerable, there was little fuel left for fires to get started. People did their best to eliminate fires from this fragile ecosystem and as a result have managed to destroy much more of the Everglades than fires did.

Fire suppression efforts usually work quite well for the first part of the dry season. By the end of the dry season when water levels are below ground, plant material is extensive, dry and available everywhere. Somehow, somewhere, a spark or lightning strike is inevitable. When fires get started under these conditions, the soil with its high organic content has dried out and actually burns. In this case the efforts of fire suppression have the opposite effect to the one intended.

The magnificent redwood trees in California have also borne the brunt of man's prejudice against fire. Before white men lived in California, these open, parklike forests handled fire as described by John Muir in 1875 when "a broad cataract of flames" moved into a *Sequoia* spp. grove and "the ungovernable flood became calm like a torrent entering a lake, creeping and spreading beneath the trees." Annual fires which had burned the debris beneath the trees prevented a buildup of litter and the associated potential for a holocaust. The United States Forest Service, from its creation in 1905, adopted a rigid antifire policy. This policy was responsible for a buildup of surface debris which, when it ignited, did considerable damage. In addition, it allowed white fir *(Abies concolor* [Gord. & Glend.] Lindl.) to seed in under the sequoia which, in turn, choked off sequoia reproduction. Not until Harold Biswell and associates of the University of California began to investigate the ecology of fire in the 1950s did it become apparent that excluding fire was the wrong approach.

Fire in the northern part of North America can be devastating. In October 1871, after five months with hardly a drop of rain, a fire in Wisconsin burned over 400,000 ha and wiped out the little milltown of Peshtigo. At the same time, 5000 km^2 of bush were burned between the French River and Lake Nipissing in northern Ontario. In 1948, a large fire near Chapleau consumed some 258,180 ha of Ontario bushland.

These fires occurred because a combination of drought, wasteful lumbering practices that provided thousands of tonnes of dead wood, and carelessness with fire brought immense destruction. Modern lumbering operations no longer leave such massive amounts of waste wood in the bush, and communications and transportation are much improved; consequently, the potential for loss of human life is much reduced.

It is important to remember, however, that forest fires in Canada are as natural as rain and snow. A very interesting presentation of historical fire records is made by Heinselman (1973), a plant ecologist with the United States Forest Service. Heinselman has spent many years working in the Boundary Waters Canoe Area, near the Minnesota-Ontario border. He finds that all the virgin forests that remain in this 400,000-ha preserve "owe their composition and structure to periodic fires over the past 400 years. In fact," he continues, "the entire biota has adapted to fire over eons of time."

Rowe and Scotter (1973) state that "the western boreal forest is a disturbance forest usually maintained in youth and health by frequent fires to which all species, with the probable exception of fir, are nicely adapted ...." There is little doubt that fire has always been a feature of the boreal forest. Lightning, which has been the major source of ignition, accounts for between 20 and 30% of all Canadian forest fires, and is responsible for most of the area burned (Johnson and Rowe 1975). The efforts of fire suppression crews have reduced the total area burned annually since pre-European colonization, but an important source of ignition remains unchanged.

In northern Ontario the forests are a complex quiltwork pattern of pure stands and coniferous/deciduous mixtures of black spruce *(Picea mariana* [Mill.] B.S.P.) white spruce *(P. glauca* [Moench] Voss), balsam fir *(Abies balsamea* [L.] Mill.), trembling aspen *(Populus tremuloides* Michx.) and white birch *(Betula papyrifera* Marsh.) that were, and still are to a significant degree, related to the fire history of the area. Paleoecological analysis of charcoal deposits in lake and peat bog sediments in the Great Lakes region indicates that there have been periodic forest fires here for at least 9,000 years (Potzger 1950, Swain 1973, Raymond 1975). The regeneration mechanisms of black spruce, trembling aspen, jack pine *(Pinus banksiana* Lamb.) and white birch following fire are, in fact, evolutionary adaptations in a fire environment. It is essential for forest managers to understand and appreciate the fundamental roles of fire, as its occurrence in the boreal mixedwood forest is inevitable. They should be aware not only of the short- and long-term effects of fire, including the consequences of attempting to exclude it, but also of the ways in which they can use fire as a managment tool.

Influence on the Physical-Chemical Environment

Fire can be an effective decomposer and mineralizing agent. Some or most of the nutrients tied up in organic material are liberated and released as ash. Later they are deposited in the soil in sufficient quantity and in appropriate chemical forms so that surviving plants experience a net improvement in their environment (Ohmann and Grigal 1979). In the absence of fire, nutrient cycles and energy flow can be partially or severely blocked by incomplete decomposition of forest biomass (Heinselman 1978).

The physical removal, by fire, of certain vegetation components within a stand naturally alters micro-climatic conditions. Increased insolation correspondingly results in higher soil temperatures which, in turn, stimulate some seeds, for example, those of pin cherry (*Prunus pensylvanica* L.), to germinate (Marks 1974) and creates the necessary environment to induce sprouting in others (Horton and Hopkins 1966).

The impact of fire on environmental site quality is often of major concern. There is speculation that released nutrients such as phosphorus might cause eutrophication problems (i.e., algal blooms) in receiving lakes and streams. However, studies by McColl and Grigal (1977) and Schindler et al. (1980) indicate that, except for an unusually short return interval and late-season fires, there are no long-lasting, detrimental effects on water chemistry or biological properties. Post-fire vegetation ties up nutrients rapidly and reduces losses.

On the other hand, fire may expose varying amounts of mineral soil and, in so doing, increase the potential for surface erosion. Severe erosion is normally associated with steep terrain and immediate, heavy post-fire rains (Lutz 1956). Nevertheless, no measurable erosion was observed during two separate surveys of wildfire sites in northwestern Ontario (Armson et al. 1973, Methven et al. 1975). Fire-induced changes in the physical and chemical properties of the forest floor are greatly dependent on the degree of duff removal. Generally, a layer of organic material remains over a large portion of the area so that direct heating of the mineral soil is minimal.

The pattern created by fire and physiography provides for a variety of stand ages, vegetation types and successional stages over the forest landscape (Alexander and Euler 1981). The vegetation mosaic as a whole changes little over time; the fire-initiated patches--"...like the pieces in a kaleidoscope --are periodically rearranged by fire and succession" (Heinselman 1978). The average number of years required to burn an area equivalent to the region as a whole is regarded as the *natural fire rotation* (Heinselman 1973) or *fire cycle* (Van Wagner 1978b). Van Wagner has shown that the stand age-class distribution in a natural, fire-controlled forest should in theory fit a negative exponential function. The average stand age would be the same as the fire cycle; two-thirds of an area would have stands younger than the fire cycle and one-third would have stands that are older. Estimates of fire cycles for near-boreal conditions are 50-100 years (Heinselman 1973, Woods and Day 1977, Van Wagner 1978b). The scarcity of forest stands older than 200 years (e.g., MacLean 1960, Lynn and Zoltai 1965) is simply a reflection of the cyclic nature of fire. Upland areas burn more often than do lowland areas, because conditions conducive to fire spread occur more frequently on uplands.

Determinant of Wildlife Habitat Patterns and Populations

Although the popular image suggests that forest fires leave charred animal bodies littering the landscape, in reality there is very little evidence that fires kill substantial numbers of wildlife. Most animals are capable of avoiding fires by burrowing, running away, flying away, or escaping into water. Except for nests containing young or newborn mammals and birds that are not yet very mobile, wild animals are not particularly vulnerable to fires. In Alaska, for example, Hakala et al. (1971) reported that two large fires covering over 30,000 ha did not cause the animals in the area to panic. A family of swans (*Olor* spp.) and a moose (*Aces alces*) moved and fed in a small lake while the surrounding forest burned to the shore. A small group of woodland caribou (*Rangifer tarandus*) rested, was encircled by the fire, then moved away. Ruffed grouse (*Bonasa umbellus*) were heard drumming in unburned pockets of trembling aspen a week after the 6,000-ha Little Sioux Fire of May 1971 in northwestern Minnesota (Stenlund 1971). The fact that fires may kill some individuals cannot be disputed, but it is questionable whether fires depress populations (Cringan 1958, Buech et al. 1977).

Small mammals such as voles, chipmunks and deer mice would be logical candidates for destruction by the fires. When scientists studied this problem on the Little Sioux Fire, they found these mammals present on the burned area shortly after the fire. They were active in even the most severely burned parts of the forests (Stenlund 1971). Apparently, they had simply gone underground during the fire and were not destroyed. Highly mobile animals like deer and moose are able to avoid the flames by running from them or moving into wet swamps and lakes. Birds, of course, fly away. Many small mammals seek protection by retreating into ground burrows and damp areas. Some animals may be caught by the flames, but the inescapable conclusion is that few are actually killed.

The long-term habitat conditions created by recurrent fire are often excellent for wildlife. Some animals react to very specific conditions created by fire while others exploit the general pattern or mosaic of vegeta-

tion. For example, the sharp-tailed grouse *(Pediocoetes phasianellus)* of northern Ontario is particularly drawn to open and semi-open areas such as those that have been recently burned over (Hansen et al. 1973, Euler 1977). Birds that nest in tree holes or cavities take advantage of the snag patches produced by fire (Niemi 1978). At the other end of the spectrum are generalists like white-tailed deer *(Odocoileus virginianus)* and moose, which use all successional stages and inhabit a wide variety of vegetation types. When the various habitat types are interspersed in close proximity, the value of the habitats to these animals is enhanced. The fire mosaic, which is predominant throughout the boreal forest, benefits both specialists and generalists. Specialists benefit because, through periodic fire, the probability is enhanced that the particular set of conditions the species requires will exist. Generalists benefit because the mosaic contains a variety of conditions usually relatively well dispersed throughout the area.

One of the generalizations of wildlife ecology that seems to have wide application throughout North America is that mature, climax forests are not highly productive wildlife habitat. Game animals, such as deer, moose and ruffed grouse do not thrive in large areas of mature forest, while non-game species are also less diverse and less numerous than those that inhabit successional stages of forest regeneration.

During the eons of time while fires were periodically changing forest composition, wild animals were evolving to exploit these disturbed areas. Moose and deer find abundant supplies of food on burned areas for many years following fire. Certain species of birds have evolved to exist in the secondary growth, edges and openings created by periodic disturbances. Of the 43 species of songbirds considered characteristic of the transcontinental coniferous forest, only 14 nest in and require mature, unbroken climax forest. The other 29 species need openings, edges or bushy undergrowth to complete their life cycle.

In Ontario, moose are the most obvious example of animals exploiting recently burned areas (Cumming 1972). This relationship has been explored in numerous studies and the overwhelming evidence is that burned areas are beneficial to moose populations (Peterson 1953, Cringan 1958, Peek 1972, 1974, Hansen et al. 1973, Krefting 1974, Irwin 1975). A five-fold increase in moose following the 1971 Little Sioux Fire was attributable initially to immigration of yearlings into the area but was subsequently sustained by increased productivity and survival.[1] Preference for the fire-created mosaic has also been noted in a number of operational surveys in Ontario. A portion of the 1941 Gogama Fire area which, apparently, was excellent moose range, was described by Vozeh and Cumming[2] with the aid of a forest resources inventory map. It consisted of 354 ha and supported 1.7 moose/km^2 in winter. Eighty-two percent of the area was composed of a stand that had reproduced following the burn 19 years earlier. It contained a mixture of tree species, 4-9 m tall, with a dense understory of shrubs and tree saplings. The remainder of the study area consisted of five rather long and narrow patches of mature conifers which constituted 18% of the total area. These stands contained patches of dense cover (8%) and were distributed around the edges of the study area. No part of the area was more than 0.5 km from a patch of mature coniferous cover.

The total moose population in Ontario is also a mosaic of population densities that expands and contracts as environmental conditions change. Moose populations have probably always fluctuated as fires disturbed various areas and as vegetation changed following those disturbances. Moose and fire have evolved together in the boreal forest and if fire were eliminated entirely, populations would certainly decrease drastically.

A dominant relationship between fire and wildlife in the boreal mixedwood forest is achieved through the particular conditions created when trembling aspen stands are created by fire. Aspen is certainly the champion of several "phoenix" tree species in the boreal forest and would not exist in the same quantity without fire. The relationship between wildlife and aspen is clear; several wildlife species find aspen stands excellent habitat (Sharp 1971, Gullion and Svoboda 1972, Peek 1972, 1974).

Fire can influence predator-prey relationships since carnivores are dependent on herbivores and therefore on the fire-created vegetative mosaic. The story of the 1936 fire-moose-timber wolf *(Canis lupus)* association on Isle Royale is a classic example (Allen 1974, Krefting 1974). Fox's (1978)

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[1] Peek, J.M. 1979. College of Forestry, Wildlife and Range Science, University of Idaho, Moscow. (pers comm.).

[2] Vozeh, G.E. and Cumming, H.G. 1970. A moose population census and winter browse survey in Gogama District, Ontario. Ont. Min. Nat. Resour., Gogama District. 31 p. (unpubl. rep.).

analysis suggests that forest fires are at least partially responsible for the cyclic nature of snowshoe hare *(Lepus americanus)* and associated Canada lynx *(Lynx canadensis)* populations.

Some animal species have been viewed as "climax species", adapted to and dependent on late successional stages of vegetation. Woodland caribou and pine marten *(Martes americana)*, for example, are usually viewed as animals associated with the mature boreal forest. For them, the hypothesis suggests, fire is detrimental because it destroys their habitat (Devos 1948, 1952, Cringan 1957, 1958). More recent studies, however, illustrate that the relationship is more complex than was once thought. Woodland caribou have been shown to survive very well in early successional areas (Bergerud 1974, Euler et al. 1976, Davis and Franzmann 1979) and fire seems to be necessary over the long term to provide the mature forest with abundant lichens (Klein 1982). Pine marten also require some form of disturbance to produce food items they need. Koehler and Hornocker (1977) concluded that fire was an important agent in establishing and maintaining a diversity of forest communities useful to marten.

Controller of Major Ecosystem Processes and Characteristics

The role of fire in regulating biotic productivity and maintaining long-term ecosystem diversity and stability in northern forests has been the focus of much discussion in the ecological literature (e.g., Mutch 1970, Dix and Swan 1971, Heinselman 1973, 1978, Wright and Heinselman 1973, Bormann and Likens 1979, Van Wagner and Methven 1980). Productivity is almost always higher in early than in late stages of forest development (Hansen et al. 1973, Rowe and Scotter 1973). Fire can stimulate an increase in net primary production through changes in the physical-chemical environment (Ohmann and Grigal 1979). Dix and Swan (1971) felt that most areas in the boreal forest have "...undergone an infinite number of fire disturbances through time followed by an equivalent number of vegetational readjustments." The forest and its environment are linked in an irregular "pulse" strategy of alternating fire disturbance and regrowth that repeatedly rejuvenates the growing stock.

The fire-created vegetative mosaic provides for a variety of habitats. In the absence of fire we would expect ecosystem-wide progression to species-impoverished stands consisting principally of balsam fir. A significant end result of recurring fires is often expressed in terms of ecosystem stability (i.e., general long-term persistence). The stabilizing function of fire is carried out by halting development and/or succession before instability becomes irreversible, i.e., before the community is radically altered (Van Wagner and Methven 1980).

Management Implications

Mutch (1970) advanced the hypothesis that *fire-dependent* plant communities had, through evolution, developed characteristics that made them more flammable. The extraordinarily high energy content and fire-brand potential of white birch bark might be regarded as such an adaptation in the boreal mixedwood forest. However, the definition advocated by Kelsall et al. (1977) is more applicable to the boreal mixedwood forest — *it is a fire-dependent system that would lose its character, vigor, and faunal and floral diversity in the absence of fire.*

Certain forest/vegetation management practices can duplicate the effects of fire and even create habitat suitable for wildlife (Dolgaard et al. 1976, Euler 1977). The ecological rationale for broadcast burning of logging slash centers on the premise that natural conditions can be approximated (e.g., Tucker and Jarvis 1967, Robinson 1970). Lower planting costs and fire hazard reduction are added benefits (Kill 1971, Vyse and Muraro 1973).

Logging and slash burning may indeed be adequate substitutes for fire but what effect has fire protection had in the uncut portions of the boreal mixedwood forest? On the basis of percent mean annual area burned for 1920-1979, calculated fire cycles vary from 200 to 1,000 years (average 500 years) in northern Ontario (Alexander 1980). There are, of course, no 500-year-old stands in northern Ontario but the present fire cycle is indicative of the increasing effectiveness of fire suppression. Logging has helped fill the gap between the burned area that would have occurred without fire protection and the area burned with fire protection. However, we may be seeing the consequences of fire exclusion already. For example, is the continuing spruce budworm outbreak being perpetuated by the existence--attributable to fire exclusion --of extensive areas of susceptible balsam fir? Are our parks becoming biologically quite different from the types of areas we planned to perpetuate?

On the other hand, one has to wonder about the economic wisdom of aggressive fire suppression. Forest fires are controlled more

by weather than by fire control forces and suppression equipment. Some 75 years ago James Douglas[3] wrote:

> "It is a question whether there could be much wisdom in spending large sums of money in a vain effort to preserve tracts of forest, only to meet their fate by fire. These conflagrations seem irresistible and the cost of preparing for a possibility of stopping them may exceed the value of the chance. Small forest fires may sometimes be influenced or partially controlled, but no way has been found to stop great conflagrations and I do not think they can be stopped."

In spite of a marked increase in suppression capability (and even with new technology) it seems that complete fire exclusion is impracticable, if not physically and financially impossible, even for those areas under active management, in view of the fire environment (multiple fire starts, fuel complexes, fire climate, terrain) and inaccessibility of much of northern Ontario. Fire control forces can easily handle fires of low or moderate intensity but very likely the frequency of large-scale, high-intensity fires will increase with a continued policy of fire exclusion. Certainly logging companies cannot tolerate random fire in areas scheduled for cutting, but buying more hose or larger planes is not the answer. Obviously an ecological-economic compromise is in order. Van Wagner (1978a, 1979a) and Martell (1978, 1980) have advocated a number of economic principles as a basis for considering fire in concert with land management in the boreal mixedwood forest. In addition Euler (1975), Marty and Barney (1981), and Lowe et al. (1978) have outlined methods by which the economic benefits of fires can be judged.

Fire is a resource no less than the physical and biological components of the environment: without fire, the ecosystems that today characterize regions such as the boreal mixedwood forest would be something different. Fire should be considered from both an ecological and a protection point of view by those developing land and resource management objectives. Furthermore, once the objectives have been set, fire-related activities should be designed specifically to meet them, and not as an afterthought when all other planning has been completed.

[3] Douglas, J. [ca. 1905]. The conservation of Canada's natural resources. (a lecture given at McGill College) Public Archives of Canada), M.G. 29, File B15, Vol. 54.

A realistic attitude towards forest fires that puts them in proper perspective considers them agents of change. Nothing in the natural world is as constant as change. Plant communities are evolving and changing, animals migrate, their populations expand and contract, insects defoliate large areas and fires burn. Plant associations begin anew and proceed from one group of species to other groups as time passes. Animal associations change as the plant species change. When forest fires burn large areas, new habitat is created for different kinds of wildlife.

Change occurred for thousands of years before people were important factors on the earth. We, of course, have made changes, too, some dramatic and some even detrimental to our species, but this is part of the natural world as well. True, we must stop fires when human lives are threatened and when they will destroy jobs by removing merchantable timber. Where possible, however, and with all due caution, we should let them burn.

Literature Cited

Alexander, M.E. 1980. Forest fire history research in Ontario: a problem analysis. p. 96-109 *in* Proc. Fire History Workshop. USDA For. Serv., Rocky Mt. For. Range Exp. Stn., Fort Collins, Colo. Gen. Tech. Rep. RM-81.

Alexander, M.E. and Euler, D.L. 1981. Ecological role of fire in the uncut boreal mixedwood forest. p. 42-64 *in* R.D. Whitney and K.M. McClain, *Cochairmen*. Boreal Mixedwood Symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-9.

Allen, D.L. 1974. Of fire, moose and wolves. Audubon 76(11):38-49.

Arnason, K.A., Taylor, J.M. and Astley, E. 1973. The effects of fire on organic layers of spodosols in the boreal forests of Ontario. Agron. Abstr. 1973:137.

Bergerud, A.T. 1974. Decline of caribou in North America following settlement. J. Wildl. Manage. 38:757-770.

Bormann, F.H. and Likens, G.E. 1979. Catastrophic disturbance and the steady state in northern hardwood forests. Amer. Sci. 67:660-669.

Buech, R.R., Siderits, K., Radtke, R.E., Sheldon, H.L. and Elsing, D. 1977. Small mammal populations after a wildfire in northeastern Minnesota. USDA For. Serv., North Central For. Exp. Stn., St. Paul, Minn. Res. Pap. NC-151. 8 p.

Cringan, A.T. 1957. History, food habits and range requirements of the woodland caribou of continental North America. Trans. North Amer. Wildl. Conf. 22:485-501.

Cringan, A.T. 1958. Influence of forest fires and fire protection on wildlife. For. Chron. 34:25-30.

Cumming, H.G. 1972. The moose in Ontario. Ont. Min. Nat. Resour., Toronto, Ont. 29 p.

Davis, J.L. and Franzmann, A.W. 1979. Fire-moose-caribou interrelationships: a review and assessment. Proc. North Amer. Moose Conf. and Workshop 15:80-118.

Devos, A. 1948. Status of the woodland caribou in Ontario. Sylva 4(1):16-23.

Devos, A. 1952. The ecology and management of fisher and marten in Ontario. Ont. Dep. Lands For., Toronto, Ont. Tech. Bull. (Wildl. Ser. 1). 90 p.

Dix, R.L. and Swan, J.M.A. 1971. The roles of disturbance and succession in upland forest at Candle Lake, Saskatchewan. Can. J. Bot. 49:657-676.

Dolgaard, S.J., Gullioh, G.W. and Haas, J.C. 1976. Mechanized timber harvesting to improve ruffed grouse habitat. Univ. Minn., Agric. Exp. Stn., St. Paul, Minn. Tech. Bull. 308 (For. Ser. 23). 11 p.

Euler, D. 1975. The economic impact of prescribed burning on moose hunting. J. Environ. Manage. 3:1-5.

Euler, D. 1977. Vegetation management for wildlife in Ontario. Ont. Min. Nat. Resour., Toronto, Ont. 62 p.

Euler, D.L., Snider, B. and Timmermann, H.R. 1976. Woodland caribou and plant communities on the Slate Islands, Lake Superior. Can. Field-Nat. 90:17-21.

Fox, J.F. 1978. Forest fires and the snow shoe hare - Canada lynx cycle. Oecologia 31:349-374.

Gullion, G.W. and Svoboda, F.J. 1972. The basic habitat resource for ruffed grouse. p. 113-119 *in* Aspen: Symposium Proceedings. USDA For. Serv., North Central For. Exp. Stn., St. Paul, Minn. Gen. Tech. Rep. NC-1.

Hakala, J.B., Seemel, R.K., Richey, R.A. and Jurtz, J.E. 1971. Fire effects and rehabilitation--Swanson-Russian Rivers fires. p. 87-99 *in* Proc. Fire in the Northern Environment - A Symposium. 13-14 April, Fairbanks, Alaska. USDA For. Serv. Pacific Northwest For. Range Exp. Stn., Portland, Oreg.

Hansen, H.L., Krefting, L.W. and Kurmis, V. 1973. The forest of Isle Royale in relation to fire history and wildlife. Univ. Minn., Agric. Exp. Stn., St. Paul, Minn. Tech. Bull. 294 (For. Ser. 13). 43 p.

Heinselman, M.L. 1973. Fire in the virgin forests of the Boundary Waters Canoe Area, Minnesota. Quat. Res. 3:329-382.

Heinselman, M.L. 1978. Fire in wilderness ecosystems. p. 248-278 *in* Wilderness Management. USDA For. Serv., Washington, D.C. Misc. Publ. 1365.

Horton, K.W. and Hopkins. E.J. 1966. Influence of fire on aspen suckering. Can. Dep. For., Ottawa, Ont. Publ. 1095. 19 p.

Irwin, L.L. 1975. Deer-moose relationships on a burn in northeastern Minnesota. J. Wildl. Manage. 39:653-662.

Johnson, E.A. and Rowe, J.S. 1975. Fire in the subarctic wintering ground of the Beverly caribou herd. Amer. Midl. Nat. 94:1-14.

Kelsall, J.P., Telfer, E.S. and Wright, T.D. 1977. The effects of fire on the ecology of the boreal forest, with particular reference to the Canadian north: a review and selected bibliography. Dep. Fish. Environ., Can. Wildl. Serv., Ottawa, Ont. Occas. Pap. 32. 55 p.

Kiil, A.D. 1971. Fire hazard from large block clearcutting in Alberta. p. 75-94 *in* Some implications of large-scale clearcutting in Alberta - A Literature Review. Dep. Environ., Can. For. Serv., Edmonton, Alta. Inf. Rep. NOR-X-6.

Klein, D.R. 1982. Fire, lichens and caribou. J. Range Manage. 35(3):390-395.

Koehler, G.M. and Hornocker, M.G. 1977. Fire effects on marten habitat in the Selway-Bitterroot Wilderness. J. Wildl. Manage. 41:500-505.

Krefting, L.W. 1974. Moose distribution and habitat selection in north central North America. Nat. can. 101:81-100.

Lowe, P.O., Ffolliott, P.F., Dieterich, J.H. and Patton, D.R. 1978. Determining potential wildlife benefits from wildfire in Arizona ponderosa pine forests. USDA For. Serv., Rocky Mt. For. Range Exp. Stn., Fort Collins. Colo. Gen. Tech. Rep. RM-52.

Lutz, H.J. 1956. Ecological effects of forest fires in the interior of Alaska. USDA, Washington, D.C. Tech. Bull. 1133. 121 p.

Lynn, R.J. and Zoltai, S.C. 1965. The Greta Lake Road Reference Area, Geraldton Site District, Site Region 3W. Ont. Dep. Lands For., Res. Br., Toronto, Ont. Res. Rep. 60. 72 p.

MacLean, D.W. 1960. Some aspects of the aspen-birch-spruce-fir type in Ontario. Can. Dep. For., For. Res. Div., Ottawa, Ont. Tech. Note 94. 24 p.

Marks, P.L. 1974. The role of pin cherry (*Prunus pensylvanica* L.) in the maintenance of stability in northern hardwood ecosystems. Ecol. Monogr. 44:73-88.

Martell, D.L. 1978. A subjective measure of forest fire management effectiveness. For. Chron. 54:159-162.

Martell, D.L. 1980. The optimal rotation of a flammable forest stand. Can. J. For. Res. 10:30-34.

Marty, R.J. and Barney, R.J. 1981. Fire costs, losses, and benefits: an economic valuation procedure. USDA For. Serv., Intermt. For. Range Exp. Stn., Ogden, Utah. Gen. Tech. Rep. INT-108.

McColl, J.G. and Grigal, D.F. 1977. Nutrient changes following a forest wildfire in Minnesota: effects in watersheds with differing soils. Oikos 28:105-112.

Methven, I.R., Van Wagner, C.E. and Stocks, B.J. 1975. The vegetation on four burned areas in northwestern Ontario. Dep. Environ., Can. For. Serv., Chalk River, Ont. Inf. Rep. PS-X-60. 20 p.

Mutch, R.W. 1970. Wildland fires and ecosystems--a hypothesis. Ecology 51:1046-1051.

Niemi, G.J. 1978. Breeding birds on burned and unburned areas in northern Minnesota. Loon 50:73-84.

Ohmann, L.F. and Grigal, D.F. 1979. Early revegetation and nutrient dynamics following the 1971 Little Sioux Forest Fire in northeastern Minnesota. For. Sci. Monogr. 21. 80 p.

Peek, J.M. 1972. Adaptations to the burn: moose and deer studies. Naturalist 23 (364):8-14.

Peek, J.M. 1974. Initial response of moose to a forest fire in northeastern Minnesota. Amer. Midl. Nat. 91:435-438.

Peterson, R.L. 1953. Studies of the food habits and the habitat of moose in Ontario. Royal Ont. Mus. Zool. and Palaeontol., Toronto, Ont. Contrib. 36. 49 p.

Potzger, J.E. 1950. Bogs of the Quetico-Superior country tell its forest history. Quetico-Superior Comm., Chicago, Ill. Spec. Publ. 26 p.

Raymond, R.E. 1975. Postglacial lakes and recent forest fire history as exhibited in inland lake sediments on Isle Royale National Park. M.Sc. Thesis, Mich. Tech. Univ., Houghton, Mich. 42 p.

Robinson, A.J. 1970. Logging by the seed tree system and prescribed burning to encourage black spruce regeneration. Dep. Fish. For., Can. For. Serv., St. John's, Nfld. Inf. Rep. N-X-42. 16 p.

Rowe, J.S. and Scotter, G.W. 1973. Fire in the boreal forest. Quat. Res. 3:444-464. [erratum Vol. 4, p. 115. 1974].

Schindler, D.W., Newbury, R.W., Beaty, K.G. Prokopowich, J., Ruszczynski, T. and Dalton, J.A. 1980. Effects of a wind storm and forest fire on chemical losses from forested watersheds and on the quality of receiving streams. Can. J. Fish. Aquat. Sci. 37:328-334.

Sharp, W.M. 1971. The role of fire in ruffed grouse habitat management. Proc. Annu. Tall Timbers Fire Ecol. Conf. 10:47-61.

Stenlund, M. 1971. Fire and wildlife. Naturalist 22(4):8-11.

Swain, A.M. 1973. A history of fire and vegetation in northeastern Minnesota as recorded in lake sediments. Quat. Res. 3: 383-396.

Tucker, R.E. and Jarvis, J.M. 1967. Prescribed burning in a white spruce-trembling aspen stand in Manitoba. Pulp Pap. Mag. Can., Woodl. Rev. Sec. 66:333-335.

Van Wagner, C.E. 1978a. Coming to terms with forest fire. p. 88-95 *in* Proc. Symp. on Forest Protection in Quebec. John Abbott College, Ste. Anne de Bellevue, P.Q. For. Dep. Tech. Rep. 3.

Van Wagner, C.E. 1978b. Age-class distribution and the forest fire cycle. Can. J. For. Res. 8:220-227.

Van Wagner, C.E. 1979a. The economic impact of individual fires on the whole forest. For. Chron. 55:47-50.

Van Wagner, C.E. 1979b. Fuel variation in the natural fire-cycled boreal forest. p. 67-69 *in* Proc. Internatl. Fire Manage. Workshop. Dep. Environ., Can. For. Serv., Edmonton, Alta. Inf. Rep. NOR-X-215.

Van Wagner, C.E. and Methven, I.R. 1980. Fire in the management of Canada's National Parks: philosophy and strategy. Dep. Environ., Parks Can., Ottawa, Ont. Occas. Pap. 18 p.

Vyse, A.H. and Muraro, S.J. 1973. Reduced planting cost--a prescribed fire benefit. Dep. Environ., Can. For. Serv., Victoria, B.C. Inf. Rep. BC-X-84. 18 p.

Woods, G.T. and Day, R.J. 1977. A summary of the fire ecology study of Quetico Provincial Park. Ont. Min. Nat. Resour., For. Fire Contr. Br., Toronto, Ont. Quetico Prov. Park Fire Ecol. Stud. Rep. 8. 39 p.

Wright, H.E., Jr. and Heinselman, M.L. 1973. The ecological role of fire in natural conifer forests of western and northern North America--introduction. Quat. Res. 3:319-328.

FIRE MANAGEMENT IN WILDERNESS AND NATURE RESERVES WITHIN ONTARIO'S PROVINCIAL PARKS SYSTEM

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Abstract.—The beneficial role of fire, both natural and prescribed, in the management of park ecosystems is discussed in detail. Emphasis is given to parks classified as wilderness or nature reserve and the potential role of fire in these park types is outlined. Some ideas on implementing a fire management policy for all provincial parks are given.

Résumé.—L'utilité des incendies naturels et du brûlage dirigé, en aménagement des écosystèmes des parcs, est discutée en détail. On insiste sur les parcs classés comme zones de nature protégée ou comme réserves naturelles et on décrit le rôle que pourraient jouer les incendies dans ces types de parcs. Quelques idées sont données pour l'exécution d'une stratégie de défense et d'aménagement de tous les parcs provinciaux.

Introduction

I wish to begin by expressing my personal satisfaction in attending this symposium and sharing with you my interest in and certain views on fire management in provincial parks. Park managers can legitimately be both advocates and opponents of fire. In the context of provincial parks, fire can be viewed as a natural process necessary for ecological management in some situations and as a hazardous destructive agent in others. This perspective reflects the Ontario Ministry of Natural Resources' (OMNR) forest fire management policy, which also recognizes both the beneficial and harmful aspects of fire.

As you might expect in a parks system comprising 139 parks with a combined area of approximately 5,476,000 ha and more than 7,500,000 visitors annually, concerns for human safety and the capital investment that these parks represent are paramount. With the addition of 149 new parks comprising another 865,000 ha these concerns will only increase.

The importance of these concerns is obvious, however. In this paper I wish to focus on the beneficial role of fire, both natural and prescribed, in the management of park ecosystems. To this end, I shall address the following objective of OMNR's fire management policy: "to utilize the natural benefits of fire in achieving Ministry objectives for land and resource management".

Apart from any general insight that this discussion may provide into fire management within provincial parks, it should serve as an introduction to subsequent papers dealing with fire management in Quetico and Ojibway Prairie parks.

In addressing the following topics, the paper will progress from the general to the specific:

- definition of and rationale for natural areas, incorporating current views on fire management within them;
- the role of Ontario's provincial parks program in preserving natural areas through a system of wilderness and nature reserves;
- a planning and management framework for fire management in provincial parks;
- some ideas on implementing a fire management policy for provincial parks.

Natural Areas: Definition and Rationale

Natural areas are defined as segments of land and water where natural features--landforms, communities, plants and animals--and natural processes prevail. As natural ecosystems around the globe have been modified or converted to various uses by man, the protection of remnant natural areas has assumed importance and active steps have been taken to preserve such areas in many parts of the world.

Protected natural areas are established for many reasons: to retain genetic and ecological diversity, to maintain ecosystem functions, and to provide opportunities for scientific research, environmental monitoring, public education and nature appreciation. The many agencies and organizations active in establishing and maintaining natural areas bear testimony to their many social and environmental values, and their valid place among other land uses.

In the strict sense, protected natural areas are free from resource extraction, development and manipulation. Therefore, they are products of natural physical and biological processes which shape their landforms, biotic communities, flora and fauna. In this regard, fire is often viewed as a natural agent, particularly in those areas set aside to represent fire-dependent ecosystems. Here, fire plays many important roles, such as that of nutrient recycling, essential to the succession and development of communities and the maintenance of ecological diversity.

Natural Areas in Provincial Parks

The perspective on fire management offered in this paper is directed toward that part of OMNR's goal aimed at the "...conservation of Ontario's natural resources."

At present this goal is achieved by adherence to principles of integrated resource management that maximize social and environmental benefits from crown lands and waters. The protection of natural areas is recognized as an important component of this goal.

Responsibility for the establishment and management of legally protected natural areas is conferred on OMNR through the Provincial Parks Act. In particular, the provincial parks policy approved by Cabinet in May 1978, and the Ontario provincial parks planning and management policies (guidelines) provide explicit direction on the establishment and management of natural areas as a component of the provincial parks system.

The goal of the provincial parks system is to provide a variety of outdoor recreation opportunities, and to protect provincially significant natural, cultural, and recreational environments in a system of provincial parks.

Issuing from this goal are four major objectives of provincial parks:

- to protect provincially significant elements of the natural and cultural landscapes of Ontario;
- to provide outdoor recreation opportunities ranging from high-intensity day use to low-intensity wilderness experience;
- to provide opportunities for exploration and appreciation of the outdoor natural and cultural heritage of Ontario;
- to provide Ontario's residents and out-of-province visitors with opportunities to discover and experience the distinctive regions of the province.

The foregoing objectives are achieved through the application of planning and management principles for the provincial parks system. These principles include a scheme for the classification and zoning of specific parks. Ranging from the most intensively protected categories to the most recreation-oriented, the park classes are: nature reserve, wilderness, historical, natural environment, waterway and recreation. Zones may be designated within any of the foregoing classes to facilitate management in compliance with the four park system objectives.

Of the six categories recognized in park policy, wilderness and nature reserve zones are the most relevant to this paper. Together, they correspond most closely to the notion of natural areas introduced in the opening remarks.

Wilderness and nature reserve zones are selected to represent the natural environmental diversity of Ontario. From an ecological perspective, a framework based on the site region classification for Ontario is used to organize this ecological diversity. Basic units for representation within each site region include natural landscape patterns, distinctive site types and representative biotic communities with their characteristic plants and animals. Through such an approach, it is possible to incorporate within a series of wilderness and nature reserve zones a cross-

section of the principal ecosystem types in Ontario.

The wilderness component provides singular opportunities to represent major landscape patterns characteristic of the northern site regions. By definition, "wilderness is a substantial area where the forces of nature are permitted to function freely and where visitors are part of the natural landscape, travelling by non-mechanized means and experiencing expansive solitude, challenge and personal integration with nature." Although wilderness serves both protection and recreation objectives, permitted activities of visitors are sufficiently restrictive that they pose little threat to the ecological integrity of protected environments. Because of size restrictions, wilderness parks are confined to northern Ontario (site regions 1E through 5E).

At present there are eight wilderness parks in Ontario:

- Quetico, about 120 km west of Thunder Bay, perhaps our most acclaimed wilderness park (475,819 ha), containing transitional conifer-hardwood and boreal forests in Site Region 4W;

- Killarney, on the north shore of Georgian Bay, our smallest wilderness park (48,500 ha), representing the unique and picturesque La Cloche Hills in Site Region 5E;

- Polar Bear, on the shores of Hudson Bay and James Bay, our largest wilderness park (2,408,700 ha), representing coastal subarctic tundra, wetlands and forests in Site Region 1E;

- Woodland Caribou, on the Ontario-Manitoba border about 80 km north of Kenora (450,000 ha), representing several distinctive and widespread landscapes in Site Region 4S;

- Opasquia, north of Sandy Lake (473,000 ha), a remote area representing several major landscape patterns in Site Region 2W;

- Wabakimi, about 200 km north of Thunder Bay (155,000 ha), mainly low-productivity terrain in the central boreal forest, Site Region 3W;

- Lady Evelyn-Smoothwater, about 100 km northeast of Sudbury, a rolling forested terrain (72,400 ha), representing tolerant hardwoods and boreal communities, in Site Region 4E;

- Kesagami, about 125 km northeast of Cochrane (55,977 ha), a flat-lying lowland containing bogs, fens, swamps and lowland forests characteristic of Site Region 2E.

Complementing these parks are eight wilderness zones within Algonquin, Lake Superior, Neys and Sibley provincial parks. Together, the existing wilderness zones contain approximately 4,251,000 ha, or about 4% of the land and water base of the province.

The other component of the system of natural areas, nature reserves, while much smaller, is no less important or diverse in character. "Nature reserves are areas selected to represent the distinctive natural habitats and landforms of the province, and are protected for educational purposes and as gene pools for research to benefit present and future generations." In this role they are complementary to wilderness parks and zones. By wilderness standards, nature reserves tend to be comparatively small in size, although there are no absolute size limits.

Until last year there were 163 nature reserves in the system including 13 regulated parks and 150 zones designated within other park classes. The establishment of 74 new nature reserves was announced by the Minister in June 1983, subsequent to the evaluation and selection of candidate parks considered through land use planning. These nature reserves comprise approximately 200,000 ha, less than .02% of the land and water base of Ontario. It would be impossible to describe all of them here, but a small sample can illustrate the diversity of environments and communities currently represented:

- Ojibway Prairie, lying within the city of Windsor, an exceptional 65-ha tract of remnant tall grass and forb prairie in Site Region 7E;

- Cavern Lake Canyon, about 70 km northeast of Thunder Bay, a 189-ha reserve in Site Region 3W, noteworthy for subarctic and tundra-like communities that persist on the floor of the canyon;

- Coldspring watershed, a 6,000 ha watershed reserve representing upland tolerant hardwoods in Algonquin Park, Site Region 5E;

- Agawa Valley, in Lake Superior Provincial Park, a 2,393-ha zone incorporating old-growth tolerant hardwood communities on deltaic deposits and Precambrian upland in Site Region 4E;

- East Sister Island, a remote 53-ha reserve in Site Region 7E, west of Pelee Island, supporting southern deciduous forests containing Carolinian species such as hackberry and Kentucky coffee tree, and an extensive heronry.

With this introduction to the system, I would now like to focus on fire guidelines and some considerations for their implementation.

Natural fires in wilderness parks and zones, and in selected nature reserve parks and zones, normally will be allowed to burn undisturbed unless they threaten human life, other zones, or lands outside of the area. Within the present series of wilderness parks, many of the areas occur within fire environments, and in all likelihood each has been burned repeatedly in pre-settlement times. Even in the short period during which fire records have been maintained, all of the areas have experienced fire. As an important natural process shaping these landscapes, natural fire should be permitted in future. This would sustain a natural mix of successional and old-growth communities for the evolution of species contained in these systems.

Likewise, natural fire in nature reserves and nature reserve zones may be an intrinsic process shaping certain landscapes and communities. Areas lying in subarctic, boreal and some lake forest zones may therefore be treated the same as wilderness areas. It is important to realize that while land managers are usually concerned with forest fires, in nature many other kinds of natural communities are adapted to or maintained by fire. Notable in this regard are prairies, but other community types including savannahs, rock barrens, grass and sedge meadows, sand barrens and dry thickets are often maintained by fire as well. Where such communities are prevalent in nature reserves, fire should be recognized as a component of ecological management.

In fragmented landscapes, where spontaneous ignition by lightning and fire-spread patterns have been altered, prescribed burns may be carried out in wilderness and nature reserves to simulate natural fires where desirable.

On the other hand, fires threatening values within wilderness and nature reserves will be suppressed. For example, it is advocated that fire suppression in East Sister Island and Cavern Lake Canyon nature reserves is desirable where fire could destroy significant Carolinian and subarctic species, respectively. And of course, fires threatening facilities in neighboring access zones will also be suppressed. However, fire suppression techniques that have minimal environmental impact will be employed wherever possible.

For those who might challenge this position on the basis that it could result in a considerable loss of timber, it should be pointed out that a relatively small amount of the area involved is productive forest (site classes 1-4). For example, Polar Bear Park is almost totally unproductive land. Of the total area of Polar Bear, Quetico and Killarney parks, only about 12%, some of which is site class 4, is productive forest land. In the 13 nature reserve parks in regulation, only 1,274 ha, or .10% of their total land base, is productive forest land. Furthermore, the exclusion of productive forest land was a major consideration in the design of recently established wilderness parks such as Wabakimi and Woodland Caribou. Moreover, the knowledge gained from monitoring the performance of fire and the response of different communities to it in protected areas could improve fire management on surrounding lands. Finally, this position conforms with the Ministry's forest fire management policy, which recognizes that "fire management is based on the values being protected...".

A Planning and Management Framework for Fire Management

I would now like to outline briefly a planning and management framework for fire management in parks.

At present, planning and management within provincial parks are guided by several related levels of planning: system planning, management planning and resource management planning.

System planning is concerned with the identification, selection and relationship of all parks. Considerations for ecological representation within the site regions of Ontario have already been mentioned as an important aspect of the selection of sites. In all subsequent decisions pertaining to the provincial park system, there is need for greater emphasis on fire management implications.

Management planning is concerned with the preparation and approval of guidelines for a specific park. The park management plan is the single most important document, since it coordinates and provides direction for all subsequent planning, development and management of the park. The park management plan documents park values, states the objectives to be achieved through park management, designates zones to facilitate management and spec-

ifies any requirements for more detailed resource management plans.

Resource management planning deals with the development and approval of detailed resource management plans--for vegetation, wildlife, and fisheries--describing specific activities to be undertaken to attain objectives specified in the park management plan.

By comparison, OMNR's forest fire management policy outlines objectives for fire management and specifies a comprehensive planning system for their delivery. Area plans prescribe the fire management objectives for a given land base or fire management zone, and delivery plans describe the administrative procedures and operating guides necessary to accomplish the specified objectives.

Accordingly, a process for planning and managing fires in wilderness and nature reserves could be developed by combining our guidelines and planning process with the policy and plan requirements set out in the policy. The result would be a park-specific fire plan, sensitive to the needs and objectives of fire management within a particular park and the surrounding region.

This park fire management plan would contain the following elements:

- the delineation of zones in which natural fires or prescribed burns are to occur;
- particulars of the burn program, such as seasonality, frequency, intensity and preferred control or suppression techniques;
- a clear outline of capital assets within the park, such as buildings, campgrounds, other facilities and specific resource areas, that require protection;
- an inventory of "values" in the park, such as capital developments, habitations, and timber resources, that require protection (in order of priority);
- a notification procedure and an emergency evacuation plan for all park users and park staff;
- a detailed monitoring program for pre-fire and post-fire information retrieval;
- precise operational procedures with assigned responsibilities for their implementation and an annual budget.

Each of these items has substantial implications for the content and preparation of a particular plan. For example, the requirement for defining fire zones necessarily introduces many considerations pertaining to human safety and fire ecology. Current principles of park zoning may need to be refined in light of these considerations.

In large wilderness parks, the desire to maintain a fire regime could be tempered by safety considerations through the designation of core area nature reserve zones where a policy of non-suppression would prevail. Where possible, these zones would incorporate several fire landscapes with natural firebreaks, such as lakes and rivers, to minimize the chance of a single zone burning in its entirety at any one time. The zone would include one or more entire watershed units and be readily demarcated by natural physiographic boundaries. Peninsulas, islands, archipelagos, or otherwise waterlocked terrain units could represent the ideal in zone design. Such core area zones could be surrounded by buffer zones, where suppression could be initiated. The buffers could be concentric in design, and bounded by a zone of intense suppression in the remainder of the park.

To develop such a plan, an amended planning process is necessary. Planning teams will have to include fire specialists who can define the requirements of a specific plan. This in turn may necessitate additional information beyond that currently gathered for management and resource management planning. Pre-fire and post-fire environmental monitoring will be essential for evaluating the achievement of objectives, and documenting the ecological effects of fire in different communities. And as important as any consideration is the cost of the undertaking and the implications for annual work planning.

Toward a Park Fire Management Policy

Although this paper portrays fire management needs being met through a neat and relatively simple process, in fact the specific nature of each situation must be acknowledged. With a phenomenon as complicated as fire, specific plans will have to incorporate some degree of flexibility and compromise in the interest of human safety and surrounding land uses. Nonetheless, with the experience gained through well conceived pilot studies, the

development of a policy and more precise planning and management guidelines for fire in provincial parks can be realized.

Several pilot studies are under way which should provide us with the information and experience we need. For example, prescribed burns, which have generally been undertaken within the foregoing planning and management framework, have been conducted at Ojibway Prairie. Here the objective has been to maintain a system of tall grass and forb prairies, one of the finest remaining examples of this ecosystem type in Canada.

On a larger scale, details of a fire management plan, also developed generally within the foregoing framework, have been worked out for Quetico Provincial Park. In implementing the plan we will no doubt gain experience that we can apply in other areas.

Pilot studies in still other situations could lead to refinements in fire management guidelines. For example, in Lake Superior and Algonquin provincial parks, fire management objectives must be reconciled with other sets of objectives, including the use of these parks for camping, a wide range of recreational experiences and timber management.

In Lake Superior Provincial Park the applicability of concentric zoning to fire management can be compared with that of other zone designs. In the northern section of the park, a series of nature reserve zones has been nestled in a substantial wilderness zone comprising five of the major headwaters within the park. Surrounding the wilderness zone are recreational utilization zones with both timber production and recreation objectives, development zones including the trans-Canada highway corridor, and natural environment zones. Here the zone design and nature of the tolerant hardwood forest communities are such that fire management may be a realistic objective in selected core nature reserve zones.

Another situation is presented by the outer islands in Lake Superior, the Lizards and Leach islands. Typically, these are flat-lying, thin-soiled environments that support mixed boreal forests. Because of the remoteness of these islands, any wildfire will be confined and will pose little threat to mainland interests. In contrast, on nearby Montreal Island, suppression may be necessary to protect recently introduced caribou.

Elsewhere in Lake Superior Park, coastal wilderness zones and isolated, interior, fire-dependent nature reserve zones immediately abut recreation utilization zones. These situations would dictate a very different attitude and suppression strategy. A critical review of these zones may require some amendments in their boundary design.

Guided by experiences such as these, I am optimistic that policy and supporting guidelines for integrating fire and park management can be prepared in the near future. A high level of coordination and cooperation among managers, specialists and planners will be necessary to ensure successful delivery of the policy and guidelines. Together we can benefit from a clearer understanding of fire and its effect on Ontario's natural resources in provincial parks.

Suggested Reading

Anon. 1978a. Ontario provincial park policy. Ont. Min. Nat. Resour., Prov. Parks Br., Toronto, Ont. Brochure 5739/1978.

Anon. 1978b. Ontario provincial parks planning and management policies (guidelines). Ont. Min. Nat. Resour., Outdoor Recreation Group, Toronto, Ont.

Anon. 1982a. Forest fire management policy. Aviation and Fire Management Centre, Ont. Min. Nat. Resour., Sault Ste. Marie, Ont. iv + 16 p.

Anon. 1982b. Provincial Parks Act. Revised Statutes of Ontario, 1980, Chapter 401. p. 1-9 *in* Provincial Parks Act, Wilderness Areas Act, 1982, Office Consolidation.

Donnelly, R.E. and Harrington, J.B. 1978. Forest fire history maps of Ontario. Dep. Environ., Can. For. Serv., Ottawa, Ont. Misc. Rep. FF-Y-6.

Hills, G.A. 1966. The ecological basis for land-use planning. Ont. Dep. Lands For., Toronto, Ont. Res. Rep. No. 46. 210 p.

FIRE MANAGEMENT IN QUETICO PROVINCIAL PARK

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Abstract.--Fire is an important element in managing wilderness parks such as Quetico Provincial Park. An active fire management program should be initiated in order to perpetuate the ecosystem for which the park was established and to prevent the forest from becoming a decadent mix of hardwoods and fir.

Résumé.--Le feu est un élément important de l'aménagement des parcs sauvages tels que le parc provincial Quetico. Il faudrait instituer un programme d'aménagement par le feu afin de perpétuer l'écosystème pour la protection duquel le parc a été créé et d'empêcher la forêt de devenir un assemblage suranné de feuillus et de sapins.

Introduction

Quetico Provincial Park is a wilderness park approximately 90 km x 60 km in size, comprising 465,000 ha of unsurpassed canoeing country. The park is located 10 km south of Atikokan, the canoeing capital of Canada (Fig. 1). Approximately 25,000 people canoe the interior each year and another 4,000 automobile campers use the Dawson Trail Campground at French Lake. Ninety percent of the users are Americans. The 1400 km of canoe routes, six entry stations and one automobile campground are managed by a staff of four permanent employees, 27 seasonal staff and 27 volunteers.

Figure 1. Location of Quetico Provincial Park

The Township of Atikokan was a mining community until 1979 when Steep Rock Iron Mines and Caland Ore Company shut down their operations and terminated 1,000 jobs. This was a heavy blow to the town of 6,000 whose economy revolved around the two mines. To replace some of the lost jobs, the Ontario government encouraged and assisted a number of construction projects such as the building of the Ontario Hydro coal-fired generating station 16 km north of Atikokan. The Ministry of Transportation and Communications has rebuilt Highway 11 (Fig. 2) and has initiated the construction of a new highway from Atikokan to Ignace. Both projects have temporarily helped stimulate local employment. However, permanent employment prospects in the future will have to rely on the forest and tourism industries. Atikokan is very dependent on Quetico as a tourist attraction and on the forests of the immediate area for fibre to feed its lumber mills.

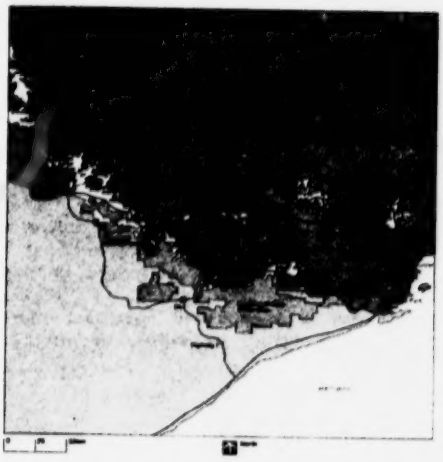

Figure 2. Highway system serving Quetico Provincial Park

Purpose

My primary purpose in this paper is to propose an active fire program for Quetico Provincial Park. I will discuss the political costs of burning in Quetico, review the Park's values, and explain the ecological benefits of using fire to manage Quetico's wilderness.

My thesis is that fire is beneficial to Quetico Provincial Park. Prescribed burns, certain man-caused wildfires, and certain naturally occurring fires should be permitted to burn in selected areas.

It was pointed out by Woods and Day (1977) in their two-year research study of Quetico's forest cover that, unless an active burn program is implemented, forest succession will revert to a decadent, uneven-aged hardwood-and-fir forest with the consequent loss of the jack pine (*Pinus banksiana* Lamb.), red pine (*P. resinosa* Ait.) and white pine (*P. strobus* L.) forests for which the park was established and for which it is internationally renowned.

Political Considerations

Timber Issue

Two mills in Atikokan are dependent on softwoods. Atikokan Forest Products in Sapawe utilize mostly jack pine for lumber. This mill, formerly operated by Domtar, was ordered by the provincial government in 1971 to stop logging in Quetico Park. This loss of timber represents 60% of the mill's 1985 requirement (Anon. 1984a). Ever since the logging ban, it has been a scramble to secure sufficient wood for the mill. Much of the wood comes from outside the district and is transported over 200 km. Approximately 300 jobs are associated with this mill.

The other Atikokan mill dependent on softwoods is Foothills Timber Company whose prime interest is white pine. Because of circumstances too complex to elaborate upon here, I will mention only that the company is carrying out a liquidation cut that will sustain it for about nine years. Thereafter, it will have to seek wood elsewhere or close the mill even though, potentially, there is white pine in Quetico. Approximately 50 jobs are associated with the Foothills operation.

From this brief review of the desperate job situation in Atikokan and the critical shortage of additional wood supplies needed to operate the two mills, you can deduce that the cost of burning harvestable trees in Quetico Park is potentially very high. A third Atikokan District mill, Pluswood, manufactures hardboard from poplar (*Populus* spp.). Since there is no shortage of poplar, there is no pressure to allow Pluswood to cut in the park.

Park Values

I shall now review the primary park values that were considered before a fire management policy was proposed for the park.

International Values

Immediately to the south of Quetico is the Superior National Forest. Approximately 400,000 ha of this Forest comprise the Boundary Waters Canoe Area (BWCA). The BWCA is an American wilderness park with goals and management objectives similar to those of Quetico. It is obvious that we must be concerned about fires crossing the international border from Quetico into the BWCA.

The United States Forest Service recently did a public review of its fire policy for wilderness parks and a decision on this issue is expected by December of this year. Briefly, it proposed to utilize prescribed burns in wilderness areas (Anon. 1984b), a view which the majority of public responses supported.

Structural Values

I shall not elaborate on this topic since our standard prescribed burn plans already give adequate consideration to the protection of structures.

Adjacent Timber Values

To the west and north of Quetico is the Flanders Crown Management Unit and to the east are the Great Lakes Forest Products Company limits. Both areas are very important to their respective mills. Consequently, before lightning fires are allowed to run their course, adequate precautions must be taken to protect these timber stands from fire. Prescribed burns should be utilized on the periphery of the park for the purpose of reducing fire "fuel", and consequently protecting the adjacent limits from fires in the park.

Native Communities and Resorts

Quetico is located in a relatively remote area of Ontario; however, the Lac La Croix Indian Reserve with 250 residents is located adjacent to the southwest side of Quetico. As prevailing winds are from the west, the reserve would probably not be in danger from fires unless a park fire originated in an area contiguous with the reserve. In addition, there are a number of resorts, tourist lodges and private cottages on all four sides of the park. These properties and the people living there are our special concern.

Recreational and Environmental Values

The effect of fires on such things as traplines, lake trout lakes, pictographs and camping areas must be given careful consideration in any fire management proposal.

For example, a large fire in the Agnes Lake area might affect the quota of visitors allowed into the park during the year of the fire. Obviously, shoreline fires will adversely affect the aesthetics of those shorelines and render campsites unusable for some time.

Northwestern Ontario and Quetico have the largest concentration of pictographs in northeastern North America. Some pictographs are vulnerable to fires because they were drawn on cliffs that are now surrounded by brush rather than water.

Proposal

Regardless of the costs I have discussed, my thesis is that Ontario is sufficiently rich in natural and cultural resources that, in the case of Quetico, Ontario can and should conduct prescribed burns in the park, allow certain man-caused fires to burn, and allow certain lightning-caused fires to burn their course.

Benefits of a Burn Program

Blowdown Hazard Reduction

In 1974 the park suffered a major windstorm that resulted in a large area of blowdown. This area has had 10 years to dry and become a potential fire hazard. It is a prime candidate for a prescribed burn for the purpose of preventing a major uncontrollable fire.

Budworm Hazard Reduction

Budworms are attacking balsam fir *(Abies balsamea* [L.] Mill.), spruce *(Picea* spp.) and jack pine and now affect about 20% of the park. If insect damage results in a significant kill of these species, it may be necessary to consider the use of fire for the purpose of reducing the likelihood that a major wildfire will destroy the park values discussed earlier.

Ecological Benefits

In 1975 and 1976, the Ontario Ministry of Natural Resources (OMNR) Parks and Fire branches jointly funded a $120,000 (in 1984 dollars) fire ecology study (Fig. 3). The purpose of the project was to study the effect of fire in Quetico. The highlights of the study are as follows (Woods et al. 1977):

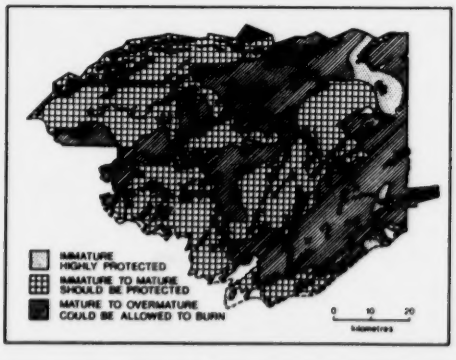

Figure 3. Ecological burn zone map of Quetico Provincial Park

1) Approximately 90% of the vegetative communities in the park consist of 'pioneer' species (jack pine, red pine, white pine, poplar and birch *(Betula* spp.). All these communities are of fire origin.

2) For thousands of years, fire has played a major role in maintaining and perpetuating these communities.

3) Before 1920 fire burned a given area every 78 years.

4) After 1940 the average increased until fire now burns a given area every 870 years.

5) The reduction of the frequency of fire from every 78 to every 870 years appears to be the result of forest fire suppression activities.

6) If this reduction of fire is continued, pioneer forests will severely decrease with time and unnatural[1], uneven-aged forests consisting mainly of tolerant hardwoods and balsam fir will steadily replace the pioneer stands. Plant and animal communities will become less productive as soil nutrients become "locked up" in layer upon layer of undecomposed organic matter (needles, leaves, branches) littering the forest floor. (A fire would quickly consume this litter, transforming it into ashes containing nutrients readily available to new growth.)

7) In order that these pioneer communities may be perpetuated in accordance with the requirements of the Quetico Provincial Park master plan (Anon. 1977), fire could be allowed to burn in the following forest types:

   a) jack pine forests 80 to 120 years old
   b) red pine forests 250 to 300 years old
   c) poplar forests 80 to 120 years old
   d) upland black spruce *(Picea mariana)* forests 90 to 120 years old
   e) white birch forests 80 to 120 years old
   f) white pine forests 250 to 300 years old

8) Fire should be excluded from young forests that have regenerated after recent logging activities and after recent burns in the park.

9) Fire should also be excluded from forests in the immature-to-mature phase so that maximum aesthetic value can be obtained. The area proposed for burning totals approximately 30,000 ha. It is proposed to burn 6,000 ha of this each year for two years and then reassess the results.

In summary, present forest stands undoubtedly exist because of past fires. In order to maintain a fire-dependent forest community, we should reintroduce fire to the park.

I propose this policy in full knowledge that 10 km from the park is the Sapawe mill which is trucking 60,000 cords of softwood per year an average distance of 200 km while we may be simultaneously burning 60,000 cords of softwood per year in the park (Anon. 1984a).

Policy

To reiterate, prescribed burns should be utilized in managing Quetico's forest, and man-caused wildfires and lightning-caused fires should be permitted to burn in designated areas.

The following are areas that should be designated for prescribed burns:

1) large blowdown areas
2) large areas of budworm-killed timber
3) boundary areas where naturally caused park fires could spread and cause damage to adjacent values outside the park, e.g., timber
4) pilot areas proposed by the fire ecology study.

Only two elements prevent the implementation of this proposal: the lack of approval of the 1978 fire management project, and the lack of adequate funding.

With respect to policy, we are permitted to implement fire management projects according to both fire policy and the park goal, which is "to preserve Quetico Provincial Park, which contains an environment of geological, biological, cultural and recreational significance, in perpetuity for the people of Ontario as an area of wilderness that is not adversely affected by human activities" (Anon. 1982).

[1] "Unnatural" forests are those in which the ecology has been altered by man, e.g., as a result of spraying against insects, putting out fires, etc.

The basic philosophy of a wilderness park is to prevent man from affecting the ecology of the park adversely. By actively suppressing park fires, man has begun to affect the forest cover of the park; the goal of Quetico Park does not prevent the use of fire as a management tool in preserving "an environment of....biological..,.significance, in perpetuity...".

Similarly, we have a permissive provincial fire policy. The following statements are taken from OMNR's policy and procedures directives for fire management (Anon. 1983):

Forest fire management: basic principle

Fire has always been a significant factor in the forests of Ontario and will continue to have an impact on people and their environment. Forest fire management is, therefore, an integral part of land and resource management.

Forest fire management: definition

Forest fire management is the strategy of fire control and fire use practised in concert with land use objectives and conducted in a manner that considers environmental, social and economic criteria.

It is also noteworthy at this time to refer once more to the change in United States Forest Service wilderness fire policy, which proposes the following objectives:

Wilderness fire policy objectives

i) permit lightning-caused fires to more nearly play their natural ecological role within wilderness
ii) reduce the risk from wildfire, or its consequences, to life and property within or to resources, life or property outside wilderness
iii) maintain fire-dependent communities if the act establishing the wilderness significally directs their maintenance (Anon. 1984b).

As you will note in Figure 2, the Boundary Waters Canoe Area is contiguous with Quetico and is also a wilderness area managed for goals and objectives similar to those of Quetico. It would therefore be appropriate to apply a similar fire management policy to both parks.

In summary I would like to say, "to preserve Quetico is to reintroduce fire to Quetico".

Literature Cited

Anon. 1977. Quetico Provincial Park Master Plan. Ont. Min. Nat. Resour., Toronto, Ont. 58 p.

Anon. 1984a. Atikokan Land Use Guideline. Ont. Min. Nat. Resour., Atikokan, Ont. 81 p.

Anon. 1984b. Federal Register. USDA, Washington, D.C. 49(109):23202-23204.

Woods, E.T. and Day, R.J.. 1977. A summary of the fire ecology study of Quetico Provincial Park. Ont. Min. Nat. Resour., Fire Ecol. Stud., Rep. No. 8. 38 p.

Anon. 1982. Revised Park Policy. Ont. Min. Nat. Resour., Toronto, Ont. 4 p.

Anon. 1983. Policy and procedures directives A.F. 03.01.01. Ont. Min. Nat. Resour., Sault Ste. Marie, Ont.

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FOREST FIRE: WHO NEEDS IT?
AN INDUSTRIAL PERSPECTIVE

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Abstract—A survey of the forest industry found relatively good cooperation in forest fire fighting activities. Both areas with which respondents expressed satisfaction and those they thought required attention are explored. The difficulties in implementing prescribed fire are examined.

Résumé—Une enquête réalisée auprès de l'industrie forestière a révélé qu'en matière de lutte contre les incendies de forêt la collaboration est relativement bonne. Cette communication examine les domaines à l'égard desquels les personnes interrogées se déclarent satisfaites ainsi que ceux auxquels, à leur avis, on devrait accorder une attention particulière. Il examine également les difficultés inhérentes au brûlage dirigé.

Dr. Filibert Roth, in his book "Forest valuation" (Roth 1925), stated that the purpose of forest management is "to build up, put in order, and keep in order a forest business." This is a particularly apt definition for the industrial forester who is responsible to his company's shareholders for the long-term successful management of both the harvesting and the renewal phases of the forest business. No longer can there be any doubt that both harvesting and renewal are an industrial responsibility. Those of us who were at the recent Woodlands Equipment Field Demonstration at Thunder Bay found ample evidence of this in the fact that silvicultural equipment formed a significant percentage of the overall demonstration. I mention this because the dual responsibilities of the industrial forester dictate that he have a "hate/love" relationship with fire. So far, most of our energy has been directed to the hate side of the relationship, but I expect that to change slowly over the next 5 to 10 years. We all hate fire because of the loss it causes. I firmly believe that significant strides have been made to lessen the impact of fire and I want to share some of my colleagues' thoughts with you on that subject. More difficult to deal with is the subject of prescribed fire (the love side of the equation). With few exceptions individual foresters have not had a great deal of experience with prescribed fire in Ontario although there is ample evidence that it can be an efficient silvicultural tool if used both appropriately and safely. In that section of my presentation I shall present my personal views as well as some encouraging results from a mini-survey I conducted this fall.

Permit me now to concentrate on our fear of fire. Who wouldn't be afraid when a wildfire such as Thunder Bay 46 in 1980 was able to destroy in a matter of days 121,000 ha of mature timber on our lakehead limits? To any industrial forester, the first prerequisite of forest management is protection from fire. That doesn't apply only to mature timber, either; the question of "why grow it if you can't protect it?" is becoming increasingly important as large sums are channelled into forest renewal activities. Are we collectively making any progress in this battle to keep fire losses to a minimum? There are several reasons why I think the answer is "yes".

In 1980 the increasing anxiety of the forest industry culminated in a report by the Ontario Forest Industries Association (OFIA) to the government of Ontario entitled *A Proposal for Participation of the Forest Industry and the Government of Ontario in Forest Fire Protection and Suppression* (Anon. 1980). The report was occasioned by two major factors:

the enormous fire losses in 1974, 1976, 1977, and 1980 and the participation of industry in the forest management agreement program in 1980. While recognizing the skills and dedication of Ontario Ministry of Natural Resources' (OMNR) fire suppression organization, the OFIA felt that two essential elements were lacking: 1) a desire to use and benefit from the knowledge and resources of industry personnel, and 2) an adequate fleet of large, amphibious water-bombing aircraft. It is not my intention to minimize the complexity of putting these two recommendations into effect. Suffice it to say that the small group of senior industry and government officials considered it more appropriate to strike a swift blow with a crooked stick than to take time out to straighten out the stick. The result, though somewhat less than perfect, is nonetheless a considerable improvement. The province is in the process of augmenting its fleet of Canadair CL-215 water bombers, and it is our hope that this fleet will continue to grow to 15 or 20, eventually replacing the aging Canso water bombers now on contract. I can unabashedly be more forceful and say that it is not only our hope but it is also necessary for our salvation.

We all know that industry has assumed the responsibility for initial attack within its own areas of operation. This has meant training crews and supervisors to OMNR standards and ensuring that their knowledge is kept current. Practice and competition are used diligently to ensure the competence of industrial fire crews.

Has it worked? I leave judgment in your capable hands after I reveal to you the results of the mini-survey I mentioned previously. The survey, of the yes/no variety, was sent to all members of the forest management and roads committee of the OFIA. It is usually the company's chief forester who sits on this committee. Sufficient responses were received (15 in all, 80% response) from large and small companies right across the province that I consider it to be a representative indication of opinion.

The answers to the following questions are expressed in terms of the percentage who answered "yes."

Q. Are you satisfied with the adequacy of OMNR fire control in terms of:

a) response time	90% yes
b) expertise	90% yes
c) adequate manpower	80% yes
d) water bomber availability	80% yes
e) use of company work force	80% yes
f) use of company equipment	80% yes
g) liaison with the company	80% yes

Q. Has the training of company fire control crews to OMNR standards resulted in a more effective first line of defence? 90% yes

Q. Are you in favor of increased company participation in fire control on your limits/FMA area? 85% yes

Q. Is fire suppression more effective (for whatever reason) now than it was 5 years ago? 85% yes

These are encouraging signs. Though only a rudimentary indication of opinion, the survey does tell me that forest protection is a shared responsibility, that we are talking to each other, that things are perceived to be better than they were, but that they aren't perfect yet.

Before we get the comfortable feeling that things aren't all that bad, let me explore some of the negative aspects of the situation. According to the Exchange of Information report issued by OMNR's Aviation and Fire Management Centre in 1984, a total of 443,655 ha were burned in 1983. The following table (which appears in the report) shows that 92% of the fires were classed as "successfully attacked" at less than 200 ha and consequently accounted for only 1% of the area burned. Congratulations! But let me question the

Table 1. The 1983 Ontario fire situation.

	No. of fires	Percentage of fires	Hectares burned	Percentage of area burned
Successful attack (<200 ha)	2,076	92	3,217	1
Escaped fires (>200 ha)	18	1	143,327	32
No action	150	7	297,111	67
	2,244	100	443,655	100

Source: Anon. (1984).

200-ha size for a "successful attack". At an average yield of 110 m^3/ha, one 200-ha burn in mature timber constitutes a loss of 22,000 m^3. I suggest to you that a divisional woods manager would face serious consequences if he viewed his mill supply assignment as plus or minus 22,000 m^3. But wait, is that 200-ha figure really as bad as it sounds? Perhaps it is in cutover that was intended for site preparation at a later date? But how do we tell? Clark (1983) points out that only 17% of the mean annual area burned across Canada from 1976 to 1980 was composed of merchantable timber. A further 8% was regeneration while the remainder (75%) was cutover and other areas. In Ontario, must we not ask if we risk misleading ourselves and the public by not making more readily available figures that can be translated into economic loss either in the current year or in future productivity?

I have a reason for raising this point. The strategic land use plans for northeastern and northwestern Ontario show an approximate balance of harvest and supply in each of these areas if neither industrial demand for fiber nor land alienation increases. The supply situation appears somewhat more precarious in the west and it is also in the west that the risk of large fires is the greatest. Forest protection must be as carefully planned and carried out as forest renewal in order to ensure that the combined efforts result in good long-term forest management. The monitoring of progress will not be possible without an accurate data base.

Two other areas of concern warrant mention in this public forum. I purposely used the word "fear" at the beginning of my presentation. Fear was evidenced in the fact that each of the companies surveyed stated that it patrolled its harvesting operation at the cessation of the day's activity if the hazard was high or extreme. The larger companies indicated that they made additional movements of men and/or equipment to strategic locations if the hazard was extreme. Whereas 75% said they were satisfied with the accuracy and reliability of the forest fire weather index, there was a surprising number of comments about the distance from the nearest data gathering station. Bluntly stated, there was doubt that the hazard index was relevant to the local area of operation. Since the industry is in partnership (at least to some extent) with the crown in fire suppression, since the stakes have never been higher in terms of values to be protected, and since cooperation is evident, should not the forest industry be part of the data gathering system and in this way have access to locally derived forest fire weather index figures?

The second point to be made is occasioned by the perception we have that management of and responsibility for fire control will become a regional office responsibility. I have no doubt that there are valid reasons for the changes being made; however, for whatever reasons, communication between OMNR and the industry, at a field level, appears to have been less than adequate in this case. Cooperation is not like a digital watch that can be set and then forgotten.

I now want to turn to the uses we can and should be making of fire for silvicultural purposes. I must confess that I was pleasantly surprised to find that 85% of those surveyed stated that their company permits prescribed burning on its limits or FMA area. I was dismayed, however, to learn that about 50% of the respondents were unaware of OMNR policies and procedures for prescribed burns. It seemed to be a case of let Alan do it. Furthermore, only 40% of those surveyed had conducted any prescribed fires in the past three years. I have but partial answers to the question about the gap between possibility and reality. These I will share with you with the caution that they are my personal opinions rather than those of the industry collectively.

I firmly believe that prescribed fire should be a tool available to every practising forester. Why? First of all, fire is natural to the forest. You can't put a shovel into the ground anywhere in northern Ontario without digging up evidence of past burns. As we struggle to find effective ways of establishing and maintaining regeneration, I feel comfortable with the method of site preparation by prescribed fire, knowing that our native species have adapted to this method over many millenia. It removes the possibility of an unrecognized ecological disaster lurking over the horizon. There is no doubt that prescribed fire is our cheapest method of site preparation. How much cheaper will obviously vary from site to site, but my experience has been that it is one half to one third the cost of comparable mechanical site preparation. And it doesn't have to be dangerous. As a result of the work done in OMNR's Northern Region--one of the only two geographical areas in which I have had experience with prescribed fire--it would seem entirely feasible to conduct the operation under low-to-moderate hazard ratings with little consequent risk of fire excursions. Indeed, of the 30 prescribed burns carried out by OMNR in 1983, only three resulted in minor excursions, and in all cases the burns were in the stage of being held at the end of the first day (Anon. 1984). This demonstrated effectiveness of OMNR fire

control is echoed in the mini-survey by a lone respondent expressing fears of a precribed fire escaping.

So why don't we utilize prescribed fire more often? One reason is that fire suppression has been dominated by an elitist group. Although this group has been highly successful in creating an effective and efficient fire suppression organization, it has been equally successful in ignoring other resource managers, or at least precluding their admittance to the group. The net result is that few field foresters have little more than a rudimentary knowledge of what will happen to a particular site if it is burned under given conditions of hazard. I understand that the formal requirements for data collection and analysis under OMNR policy and procedures for prescribed burns are quite stringent. This provides a ready-made opportunity for the foresters, both industrial and government, to conduct on-site discussions with their colleagues from fire management. It is to be hoped that both parties will avail themselves of the opportunity to teach as well as learn from each other. Once we get to the stage at which a forester can recognize sites suitable for prescribed burning and worth exploring further with his fire colleagues, a large hurdle will have been negotiated. Our current impediment to progress has been succinctly described by the well-known author, E.F. Schumacher: "When the level of the knower is not adequate to the level (or grade of significance) of the object of knowledge, the result is not factual error but something much more serious: an inadequate and impoverished view of reality" (Schumacher 1977).

A considerable percentage of field people I have spoken to have expressed a lack of conviction that the desired results can be obtained by the use of fire, or that such results, even if they were obtained once through luck, could be duplicated. There remains a need for greater exposure to on-site burns as well as to published documentation such as OMNR's "Forest managers' photo guide to prescribed burn planning" (Wearn et al. 1982). Surprisingly, only four of the 15 survey respondents had ever heard of it.

Of major concern is the length of time required to plan for a prescribed burn. As I understand it, we must apply at least a year and a half in advance of the ignition date. A forest manager must either have a surplus of site-prepared area or, alternatively, be ready to rely heavily on OMNR to carry out the burn as planned. The increasing rigidity of the FMA planning process--be it plan amendment, budget, class environmental assessment, public consultation or harvesting scheduling--leaves little room for plan changes without major disruption. I suspect that this rigidity could cause problems. For example, what happens if you can't carry out (for whatever reason) the early fall prescribed burn planned a year and a half in advance? Can you adapt to more expensive mechanical site preparation in time to get the area prepared for next spring's planting? Such considerations would cause me sufficient anxiety to limit the size of my prescribed burn program for site preparation to a small percentage of my overall program. However, I have no doubt that careful planning bolstered by a good track record over time will change the picture in the future.

As a final reason for the infrequent use of prescribed fire, I offer the suggestion that there has been no incentive for the forest manager to risk innovation. This is now changing. The rising costs associated with the FMAs mean that we have a more expensive cubic metre of fiber going into the manufacturing process. Let me be perfectly clear in stating that we are firmly committed to the FMA principle and consider our investment in forest renewal a cost of doing business. Nevertheless, it is a fact of life that we conduct our business in an extremely competitive global market. Industrial forest managers are already facing strong pressure to re-examine the traditional methods of achieving cost-effective forest management. And rightly so--this is a forest business.

I have spoken of prescribed fire only in terms of site preparation. The mini-survey results reinforced my suspicions that we tend to shy away from innovation. No interest was demonstrated in the use of fire in stand conversion, sanitation, understory removal or improvement of wildlife habitat. There is an interesting example of how fire might have been used for sanitation purposes on the Abitibi-Price White River FMA. This area was relatively free of spruce budworm infestation, but unfortunately it was burned by wildfire after it had been harvested, and the young balsam regeneration and the seed source of this prolific seeder were consequently lost. It can truthfully be said that, if fire is a tool, it is being held in the hands of those unskilled in its use.

It is doubtful that the public shares my conviction that prescribed fire should be a part of a forester's tool kit. After we have spent untold millions to persuade the public that fire is a dangerous and destructive force, how do we present a credible case for the use of prescribed fire? I consider it to be far from an idle question in view of the

degree of public involvement in the planning process. I make no pretense at expertise in this field but suggest that the prescribed fire message is, along with the still required prevention message, something which could be handled in the private sector. As a thought, could it be combined with the Smokey the Bear program at the school level by the Ontario Forestry Association?

In summary, I must reiterate that forest management is impossible without fire management.

Literature Cited

Anon. 1980. A proposal for participation of the forest industry and the government of Ontario in forest fire protection and suppression. Ont. For. Ind. Assoc., Toronto, Ont. 12 p.

Anon. 1984. Exchange of information—province of Ontario 1983. Ont. Min. Nat. Resour., Aviation and Fire Management Centre, Sault Ste. Marie, Ont. Report No. 155. 21 p.

Clark, W.R. 1983. Forest depletion by wildland fire in Canada, 1977-1981. Dep. Environ., Can. For. Serv., Chalk River, Ont. Inf. Rep. PI-X-21. 13 p.

Roth, F. 1925. Forest regulation. 2nd ed. George Wahr Publ. Co., Ann Arbor, Mich.

Schumacher, E.F. 1977. A guide for the perplexed. Harper and Row, New York. 147 p.

Wearn, V.H., Springer, E.A. and Lesage, A.J. 1982. Forest managers' photo guide to prescribed burn planning. Ont. Min. Nat. Resour., Kapuskasing District. 48 p.

FIRE AND FOREST MANAGEMENT

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Abstract.--The uses of fire in forest management are discussed both historically and in terms of the present situation in Ontario. Current impediments to the use of fire and the implications for future use are considered. A proposal is described that is based on a forest management strategy dealing with both the 'old' and the 'new' forest.

Résumé.--Cette communication examine l'utilisation du feu en Ontario par les forestiers d'hier et d'aujourd'hui ainsi que les difficultés inhérentes au brûlage dirigé et les conséquences pour l'avenir. Il présente une proposition fondée sur une stratégie d'aménagement forestier visant à la fois "l'ancienne" et la "nouvelle" forêt.

I was asked by the symposium organizers to comment specifically on three aspects of fire management:

1) How forest managers view the current situation in fire management,

2) What should be done to alleviate their concerns,

3) How fire management and forest management objectives might be integrated.

Obviously, I was being asked to be provocative, and so I intend to be. I shall provoke not by inciting to anger and creating confrontation, but rather by stimulating your thought processes in the hope that productive action will result. The former type of provocation merely reinforces and entrenches existing positions, whereas the latter breaks through the accepted positions and myths and challenges us to re-examine and analyze critically both our own positions and those of others.

A colleague recently drew my attention to a statement by Heinrich Cotta, first published in 1816 and reprinted in the Forestry Quarterly in 1902. Cotta was expressing his opinion about why forestry was so backward:

"Three principal causes exist... first, the long time which wood needs for its development; second, the great variety of sites on which it grows; thirdly, the fact that the forester who practises much writes but little, and he who writes much practises but little.

The long development causes that something is considered good and prescribed as such which is good only for a time, and later becomes detrimental to the forest management. The second fact, causes that what many declare good or bad, proves good or bad only in certain places. The third fact brings it about that the best experiences die with the man who made them, and that many entirely one-sided experiences are copied by the merely literary forester so often that they finally stand as articles of faith which nobody dares to gainsay, no matter how one-sided or in error they may be".

I quote this at some length because as a statement by a German forester made 168 years ago it has equal application to our own situation.

Generally, foresters have relied upon the argument that long rotations and diversity of sites make forest management something special that should exempt it from the more critical scrutiny to which normal business ventures are subjected. When it comes to forestry practices, lack of documentation has been one of the profession's greatest weaknesses.

Frequently, the practitioners have been doing the right things, but for the wrong reasons. When, infrequently, practitioners take to writing about the whys and wherefores of their practices we can be sure that the mythology of forestry will be enhanced.

How fire management is viewed by forest managers must therefore be placed in a historical context. It is a context that includes not only the forestry profession and forest sector at large but, perhaps even more important, the society within which we function and to which ultimately we are responsible.

We know that the forests of this region were, before the coming of European man, largely of fire origin. Most of these fires were not caused by human agents, but in certain areas the natives burned intentionally, as part of their shifting agriculture in southern Ontario, as an aid to hunting or for defensive and offensive purposes in warfare.

Settlement by Europeans, and clearing and lumbering operations in both the 19th and 20th centuries, increased the frequency of fires and led to the development of major efforts in fire suppression. To the public and many forest managers fires are to be prevented, categorically. Uncontrolled fires destroy forest growing stock, and therefore they must be prevented, or at least minimized.

But the picture is not black and white. There are forest managers who, contrary to what I have just said, make use of fire in prescribed burning. In fact, one of the greatest assets of the forest manager who wishes to use prescribed fire to achieve a specific management objective has been the availability of modern technology developed expressly by those engaged primarily in fire prevention. Some part of that technology comes from as far afield as western Australia --a point I make to underscore the need to step outside our parochial boundaries both professionally and geographically if we are to make progress.

Some forest managers use fire but significant numbers do not, perhaps because of the risk involved, but perhaps also because they are unwilling to innovate and shoulder an additional responsibility. What of the general public? To them fire is still a destructive, not a productive, agent because they have been inculcated with this belief.

We have not communicated the facts about prescribed burning to the public, but then we haven't even communicated well amongst ourselves. In Ontario, prescribed burning began in 1925 with piling and burning of slash to reduce skidding costs and continued into the 1930s as a means of clearing hazardous areas of slash. The first recorded use of prescribed burning with silvicultural objectives was in 1941, and from the 1950s to the present some form of prescribed burning has taken place annually. The main purpose of these fires has been site preparation. What is notable is that site preparation by prescribed burning accounts for less than 10% of the annual area that is site prepared.

The impediments to greater use of prescribed burning for silvicultural purposes cannot be attributed totally to a lack of trained staff, for some trained staff are available. Their first responsibility, however, is the suppression of wildfires. If specialized services are to be provided there is a greater need to have them dedicated to prescribed burning. In addition, forest managers who write the prescriptions for sites to be treated must improve their technical and professional knowledge and expertise. In this respect they have as much to learn from the fire specialist as the fire specialist has to learn from them.

To achieve this objective, however, we must ensure that there is integration of forest and fire management at the planning stage. We cannot accept the administrative division between fire specialists in Aviation and Fire Management and field foresters as an excuse for lack of such integration. The attitude of district managers is critical in bringing about integration of planning and successful implementation of management plans.

Rather than dwell on what might be accomplished, however, I prefer to put before you certain of our concerns in forest management as they relate to the use of fire. We have been looking at our northern forest in terms of its capacity, as it is brought under management, to provide timber in the near and more distant future. For the sake of simplicity we speak of the 'old' and the 'new' forest. The 'old' forest is made up of growing stock beyond, at, or approaching maturity. The 'new' forest consists of the young and intermediate-aged growing stock. Both the 'old' forest which is to be harvested and the 'new' forest must be protected from fire. The age classes in many of our management units

are not in balance. In many there is a preponderance of mature to overmature stands and access is in many instances neither uniform nor adequate. We cannot be effective in our overall forest management if we focus solely on harvesting the oldest stands and on regenerating current cutovers.

Given the objectives of maintaining an adequate timber supply over time in any given forest, the forest manager has now to view the management of these two components--the 'old' and the 'new' forest--as providing a set of challenges different from that which he has normally considered. Among the strategies which may be employed, fire management--and the extension of prescribed burning in particular--will play an important role.

We have used prescribed burning almost exclusively as a tool in site preparation. Even in this area we must do two things: first, we must increase our capability for prescription and implementation; and second, we must extend the use of fire for this purpose to areas where it has not been used or has been under-utilized because of human prejudice.

In the long run, however, the use of fire must be increased if we are to address the manner in which we deal with the 'old' forest in particular. If we are to change age class distributions by converting overmature boreal stands to newly regenerated forests, primarily of black spruce *(Picea mariana* [Mill.] B.S.P.) and jack pine *(Pinus banksiana* Lamb.), prescribed burning is virtually the only feasible tool available. We know that these stands will revert to boreal stands following natural fire and that both ecologically and silviculturally comparable 'new' forests will occur. Related to this is the use of fire in boreal forests for fire hazard reduction or sanitation as in areas of blowdown or spruce budworm infestation. The prescriptions and criteria for these three situations--overmature forests, fire hazard reduction and sanitation --have yet to be adequately developed for general management purposes. Their development is, however, dependent on the forest manager's having an overall planning strategy for the forest in which the cost/benefit relationships of investment in various silvicultural treatments ranging from regeneration to tending, protection and harvesting, with all attendant costs including those of access, are fully explored.

This, however, is only the beginning. The cost/benefit relationships I refer to cannot be estimated unless the factors of productivity and location are also taken into account. Take, for example, a spruce or jack pine working group in a forest with a preponderance of mature to overmature age classes. The calculated allowable cut based on existing age classes and site productivity requires a specified major capital investment in access. To what degree can the oldest stands be left unaccessed for the next 40 years and converted to 'new' forests by the use of prescribed fire while the allowable cut comes from younger but merchantable stands or more productive sites that are regenerated immediately to form a 'new' forest with a reduced rotation age?

The use of fire to manipulate species composition in our forests has not been developed to any great extent. Yet in certain forests--and I believe some pine plantations in southern Ontario provide an appropriate illustration--fire is an obvious tool to use in controlling low-quality hardwood infiltration. The use of fire to control understory vegetation in tolerant hardwood stands was developed by provincial research staff more than two decades ago.

Currently fire is used mainly for site preparation, but even here it is used sparingly. Prescribed burning offers the opportunity to use fire as a cost-effective treatment on many areas where the cost of access is prohibitive or the use of mechanical treatments is not feasible.

The proposal to extend the use of fire in our forest management plans therefore requires not only a significant change in our professional approach but, concurrent with that, a conscious effort to communicate with and demonstrate to our public that this approach is environmentally and economically sound. In order to do this we must increase our knowledge of both the forest and the land on which it grows and relate that dynamic inventory of growing stock and productive location to the short-, medium- and long-term demands for timber and to other demands that are placed on the forest.

Up to this point I have refrained from mentioning the forest industry. It has its own advocates at this meeting. I would stress, however, that the primary reason and justification for managing crown forests are the economic benefits that flow from the supply, processing and sale of forest products on the world market. The forest industry is a cornerstone of the economic well-being of northern Ontario. Other uses and products of the forest are important and must be taken into account, but the principal output is timber and the products into which it can be converted. The challenge in forest management is

to increase the ability of our forest sector to compete economically in the world market in the future, and I am convinced that fire management must play a significant part in this process.

Acknowledgment

I would like to pay tribute to the late R.M. Dixon, R.P.F., who in 1982 provided me with much background material on the subject of prescribed burning, some of which I have incorporated in this paper.

Mr. A. van Fraassen was also helpful in the development of this paper.

SESSION II

MEETING THE CHALLENGE

HISTORY AND NATURAL ROLE OF FIRE IN ONTARIO[1]

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Abstract. This paper examines fire regimes and the methodology employed in defining these regimes during the suppression, presuppression and post-glacial periods in the boreal and Great Lakes-St. Lawrence forest regions of Ontario. Written accounts, tree-ring and fire-scar dating and mapping of fire patterns are reviewed.

Résumè. La présente communication porte sur les régimes des incendies et sur les moyens de les définir durant les périodes de suppression et de présuppression et le postglaciaire, dans les régions des forêts boréales et des Grands Lacs - Saint-Laurent: témoignages, datation par les cernes annuels et les cicatrices d'incendie, et cartographie des formes d'incendie.

Introduction

Resource managers have a problem: they must balance the fact that fire exclusion in our forests is often impracticable and undesirable; on the other hand, total relaxation of fire protection is intolerable. As a result they are faced with the challenge of coming to terms with forest fires in land management. They should start from a position of knowledge and strength by trying to understand the natural forest fire regime prior to the initiation of fire suppression.

Sharpe and Brodie (1931) remarked that "throughout Ontario, with the exception of swampy areas, there are probably few timber stands without their fire history." The quiltwork pattern of stands in northern Ontario suggests that random, lethal, stand-replacing fires are characteristic of the area. Clarification of the fire regime requires information on both the temporal and spatial pattern of burning.

The purpose of this paper is to report on some aspects of forest fire history in Ontario. It is based on a review of published literature, unpublished reports, personal contacts, written historical accounts and personal field experience. The analysis is restricted to the boreal and northern Great Lakes-St. Lawrence forest regions of Ontario. The paper is organized into three time periods: modern (since 1920), presettlement (1600-1920), and paleoecological (recent deglaciation).

Forest Ecosystems of Ontario

Rowe's (1972) *Forest Regions of Canada* indicates that three of Canada's eight major forest regions occur in Ontario. The deciduous forest region, which is restricted to the southwestern part of the province and a thin strip along the north shore of Lake Ontario, occurs only in Ontario. The natural forest vegetation of this region has been mostly eliminated by settlement and urbanization. The Great Lakes-St. Lawrence forest region extends north from Lake Ontario to a line running between Wawa on Highway 17 north and Kirkland Lake on Highway 11 north. The most

[1] A more detailed version of this paper entitled "Forest Fire History Research in Ontario: A Problem Analysis" was originally presented at the Fire History Workshop, Univ. Arizona, Tucson, Ariz., 20-24 October 1980, by M.E. Alexander, Fire Research Officer, Can. For. Serv., Edmonton, Alta.

outstanding vegetational features of this region are the eastern white pine (*Pinus strobus* L.) and the red pine (*P. resinosa* Ait.) forests. These forests also contain a number of other conifers and several deciduous species, so that there are many mixed stands. Much of the area has been influenced by settlement, and logging has left only portions of the original vegetation. The remaining Ontario northland is part of the boreal forest region of Canada. The major tree species are jack pine (*P. banksiana* Lamb.), black spruce (*Picea mariana* [Mill.] B.S.P.), white spruce (*P. glauca* [Moench] Voss), balsam fir (*Abies balsamea* [L.] Mill.), trembling aspen (*Populus tremuloides* Michx.), and white birch (*Betula papyrifera* Marsh.). Unexploited forests still exist in large blocks. In summary, the province presents a continuum, ranging from deciduous forests in the south to largely coniferous forests in the north.

There are three major physiographic regions in Ontario (Rowe 1972). The Hudson Bay Lowland is a poorly drained region with an abundance of bogs and shallow lakes. The Canadian Shield underlies the remainder of the boreal forest and most of the Great Lakes-St. Lawrence forest. The Shield has a hilly topography characterized by Precambrian bedrock covered with a shallow layer of stony sandy till. There is an extensive network of streams, rivers, lakes and bogs. The Great Lakes-St. Lawrence physiographic region covers basically the same portion of southern Ontario as does the forest region of the same name. It is a gently sloping plain underlain by clay soils.

Precipitation is a principal determinant of fire climate in Ontario. The mean total annual precipitation increases from west to east and from north to south (Chapman and Thomas 1968). The incidence of lightning decreases from west to east. Lightning fire density, which has been mapped for the period 1965-1976 (Stocks and Hartley 1979), is significantly higher in the west than in the east. This may be due partly to the interaction of high lightning occurrence and low precipitation in the west in comparison with low lightning incidence and high precipitation in the east.

Modern Fire Record

Formal fire reporting by the provincial forestry service (now the Ontario Ministry of Natural Resources [OMNR]) began in 1917. The first attempt to summarize area burned in Ontario was included in the 1947 Ontario Royal Commission on Forestry (Anon. 1947). More recently, Donnelly and Harrington (1978) have compiled a detailed atlas of fires covering 200 or more hectares for the period 1921-1976. About 95% of the total area burned is represented by these fires. Woods[2] has produced a colorful summary of the atlas in the form of a single map of Ontario. The same fire boundaries are included but the fires are color-coded by decade. In addition, Donnelly and Harrington's (1978) original maps have been updated regularly by OMNR since 1976. Figures for area burned, by decade, that were first reported by Harrington and Donnelly (1978), have been updated by Alexander[1]. On the basis of these figures, the present fire cycle in northern Ontario is about 500 years. This probably reflects the increasing effectiveness of fire control in this century.

Presettlement Fire Records

Written Accounts

There were two large fires in Ontario before 1920. In 1911, 73 people died as 2,238 km^2 burned between the towns of Porcupine and Cochrane. In 1916, 224 people perished at Matheson when 2,590 km^2 burned. Numerous other accounts of forest fires that occurred before provincewide reporting was begun can be found. A few examples will be mentioned here.

Some of the earliest written accounts of forest fires come from Jesuit priests who served at missions throughout North America. Europeans who traversed the country also chronicled fire occurrence. The explorer Alexander MacKenzie reported large fires north of Lake Superior in 1788 and 1789[3].

Records from fur trading companies contain entries of forest fires near established posts. Charles McKenzie, a Hudson Bay Company trader, reported that a large part of territory between the Winnipeg River in Manitoba and Osnaburgh House in northern Ontario burned in 1825 (Bishop 1974).

The field notes and maps of Ontario provincial land surveyors provide invaluable fire data (Weaver 1968). An excellent example is the account of a large survey in northern

[2] Woods, G.T. 1983. Forester, Ontario Ministry of Natural Resources, Aviation and Fire Management Centre, Sault Ste. Marie, Ont.

[3] Leslie, A.P. 1954. Large forest fires in Ontario. Ont. Dep. Lands For., Toronto, Ont. 16 p. (unpubl. rep.).

Ontario in 1900 (Anon. 1901). From this account we know that a large area from west of Lake Superior to as far west as Rainy Lake burned in 1845. Interestingly, Stocks et al.[4] have investigated a large fire in the Sachigo Hills, 300 km north of Red Lake, which also dates from approximately 1845.

Geological surveys have also provided a source of fire history. During travels in 1888 through the Hunter Island area (now Quetico Provincial Park) Smith (1892) remarked on three periods of fire: 1870, 1879, and 1885-1886. He also provided a list of lakes whose shores carried the evidence of the fire disturbances.

The respective roles of lightning and man as ignition sources is not known clearly. There is no doubt that man has been a factor in the proportion of area burned (Richardson 1929, see also footnote 3) as a result of camp fires. He has also been responsible for fires associated with prospecting and the building of railroads. There were fires in 1891 and 1896 along the Canadian Pacific Railroad line (Richardson 1929) between Pogamasing (north of Sudbury) and Woman River, a distance of 129 km.

The extent to which natives used fire in their cultural activities is difficult to assess. They were aware that young vigorous forests were usually the most suitable habitat for a large variety of animal and plant species. Indian bands probably set fire to selected areas in order to manipulate the forest. Consequently, over the long term, most of northwestern Ontario was burned by the Indians.

Tree-ring and Fire-scar Dating

At the turn of the present century the connection between forest fires and pine regeneration was not clear. Braniff (1903) suggested that, in Minnesota, aspen and birch stands succeeded fire whereas jack pine was a remnant of the original forest. Less than 30 years later Richardson (1929) set the issue straight when he wrote "...strange as it may seem, the magnificent pineries composed as they were of trees nearly all of the same age, were the result of forest fires which occurred some time in the distant past." The great pines are a reliable source of fire dates, but there is a period between the time a fire occurs and the time natural regeneration begins, and this period must be taken into account when one is counting tree-rings to determine exact fire dates. Jack pine is an especially good colonizer following fire and its rings are easy to count. Ring counts of aspen and birch are very difficult to assess.

Red and white pine have maximum life spans of 400 years, although the latter is more prone to decay and is less likely to survive fire because of its thinner bark. White and black spruce may live for up to 250-300 years. Jack pine stands seldom survive beyond 200 years. One of the oldest jack pine stands in Ontario (ca. 1772 fire origin) is found along the Aubinadong River east and north of Sault Ste. Marie, Ontario.

Jack and red pine are the most abundant sources of live basal fire-scar material. Double fire-scars are common on jack pine and triple scars are rare in forests where fire suppression has been in effect for the last 60 years. In a natural fire regime in the Sachigo Hills north of Red Lake, triple scars were much more prevalent and even one tree with four scars was found. Red pine has a great resistance to decay after fire scarring. A specimen (ca. 1671 origin) with two fire-scars was taken north of White River and a second one (ca. 1731 origin) from 15 km west of Sault Ste. Marie is on display at the Great Lakes Forest Research Centre in Sault Ste. Marie, Ontario. This latter scar was found during a fire history study documented by Dominy (1981).

Dead fire-scar material has been found to be an invaluable means of obtaining extended fire chronologies. A dead snag could have two scars corresponding to scars on a living tree, yet the snag could also have one or more scars that date further back.

Turner (1950) reconstructed the fire history for several spruce budworm test sites using tree-ring counts and basal fire-scars. In the Mississagi River area east and north of Sault Ste. Marie, he found in 1946 that the ages of most white, red and jack pine stands were all between 160 and 165 years.

Howe (1915) examined the forest east of Peterborough, Ontario. Using tree-ring counts on aspen and fire-scars from red and white pine he documented fires in 1880, 1890, 1895, 1897, 1899, 1905, 1907 and 1910. A cross-section from a single fire-scarred red pine snag showed that it had been scarred when it was 25, 43, 55, 64, 82, 88, 96 and 100 years old. This gives a fire cycle of 12.5 years.

[4] Stocks, B.J., Lynham, T.J., Hartley, G.R. and Mason, J.A. 1984. Fire history work being completed by the Canadian Forestry Service, Great Lakes Forest Research Centre, Sault Ste. Marie, Ont.

Bickerstaff (1942) reported that most of the area on which the Petawawa National Forestry Institute is now located was burned in 1647, 1716, 1748, 1832, 1862 and 1875. The average fire cycle was 37 years (Burgess and Methven 1977).

Cwynar (1977) used red pine fire-scars to chronicle the fire history of Barron Township in Algonquin Park, Ontario. He documented 16 fire years between 1696 and 1920.

Woods and Day (1976, 1977) reconstructed the presettlement fire history of the Hunter Island portion of Quetico Provincial Park by aging wedges of basal fire-scars and increment bores of fire-origin stands.

A study in Pukaskwa National Park on Lake Superior north of Wawa is being completed by M.E. Alexander. Increment cores and basal fire-scars will verify the chronology of fire years. Written accounts have been obtained to help verify fire dates. The climatic history of the park as it relates to fire incidence is also being investigated by dendroclimatologists at Forintek in Vancouver, British Columbia.

Mapping Fire Patterns

Fry[5] notes that "...an age-class distribution map for a management unit in northern Ontario is little more than a mosaic that visually tells us where fires burned, when they burned and what they looked like in terms of area covered."

Howe (1915) was able to produce a fire incidence map for his research area east of Peterborough by using fire-scar and tree-ring data collected from cruise lines. Cwynar (1977 and footnote 6) did not produce boundary maps but he did map fire-scar locations and fire-initiated forest stands separately. This method gives a rough indication of the extent of a fire.

Woods and Day (1976) initially produced a burn period map for their Hunter Island study from 1975 data, forest resource inventory data and interpretation of aerial photos. This was combined with further information from 1976 to produce a final map with burned areas delineated by decade intervals back to 1770 (Woods and Day 1977). Over 75% of the study area was burned over between 1860 and 1919. Stand origin and fire history maps for Pukaskwa National Park are being produced from tree-ring and fire-scar data tied to inventory maps and aerial photo interpretation.

Harrington (1976) has used satellite imagery in a pilot study to map fires near Trout Lake in northwestern Ontario. Kourtz[7] used Landsat satellite imagery to map and obtain area estimates for a large fire in the Northwest Territories so that a discrepancy in area burned, between what native people claimed and government officials estimated, could be settled.

Paleoecological Fire Record

The oldest positive evidence of fire in Ontario comes from charred wood remains found 60-90 m below the surface at the Scarborough Heights near Toronto (Penhallow 1904). Dates go back 60,000 to 70,000 years to the early Wisconsin glacial period. Terasmae (1967) attributed the consistently high percentages of jack pine and white birch pollen found in core sediments from Nungesser Lake in northwestern Ontario to frequent forest fires in the region throughout postglaciation.

The only charcoal studies of lake sediments combined with pollen analysis undertaken in Ontario are confined to Algonquin Provincial Park. Cwynar (1978) concluded that the simultaneous presence of charcoal and pollen peaks in a 500-year core of lake sediment shows that fire has been a natural force throughout the park. Six distinct peaks from 770 to 1270 A.D. suggested a fire cycle of about 80 years. This agrees well with Woods and Day's (1976) presettlement fire cycle of 66-100 years in Quetico Park.

The study of charcoal and pollen analysis may be limited to meromictic lakes (lakes where mixing does not occur) where settling is not disturbed by mixing and flow patterns. The Experimental Lakes Area south of Kenora and Dryden is known to contain several meromictic lakes.

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[5] Fry, R.D. 1976. Prescribed fire in the forest. Paper presented at the Ontario Ministry of Natural Resources prescribed burning seminars 23-25 November, Quetico Centre and 30 November - 2 December, L.H. Frost Natural Resources Centre). 82 p.

[6] Cwynar, L.C. 1975. The fire history of Barron Township, Algonquin Park. M.Sc. thesis, Univ. Toronto, Toronto, Ont. 119 p.

[7] Kourtz, P.H. 1980. Research Scientist, Petawawa National Forestry Institute, Chalk River, Ont. (pers. comm.).

Conclusions

Maps of area burned on a provincewide scale have been prepared from fire report information for the period since 1921. Written accounts prove to be useful sources of data on fire occurrence between ca. 1700 and 1920. Tree-ring and fire-scar dating can also be used to reconstruct fire patterns during that period. Examination of fire history dating back to the end of pleistocene glaciation has been successful on a few sites but could be extended to other locations. Man has altered the presettlement fire cycle of 66-100 years to a current cycle of about 500 years.

Literature Cited

Anon. 1901. Report of the survey and exploration of northern Ontario, 1900. L.K. Cameron, Toronto, Ont. 294 p.

Anon. 1947. Report of the Ontario Royal Commission on Forestry. Baptist Johnston, Toronto, Ont. 196 p. + maps.

Bickerstaff, A. 1942. Comparison of costs and silvicultural results of various improvement cutting methods. Can. Dep. For., Chalk River, Ont. Establ. Rep. Project 44, 18 p.

Bishop, C.A. 1974. The northern Ojibwa and the fur trade: A historical and ecological study. Holt, Rinehart and Winston of Canada, Ltd., Toronto, Ont. 379 p.

Braniff, E.A. 1903. The proposed Lake Superior Forest Reserve, Lake and Cook counties, Minnesota. Official report in files of Superior National Forest, Duluth, Minn. 8 p.

Burgess, D.M. and Methven, I.R. 1977. The historical interaction of fire, logging, and pine: A case study at Chalk River, Ontario. Dep. Environ., Can. For. Serv., Chalk River, Ont. Inf. Rep. PS-X-66. 18 p.

Chapman, L.J. and Thomas, M.K. 1968. The climate of northern Ontario. Dep. Transp., Meteorol. Br., Climatol. Stud. No. 6. 58 p.

Cwynar, L.C. 1977. The recent fire history of Barron Township, Algonquin Park. Can. J. Bot. 55:1524-1538.

Dominy, S.W.J. 1981. The role of fire in Parke Township, Sault Ste. Marie, Ontario. Undergraduate Thesis, Lakehead Univ., Thunder Bay, Ont.

Donnelly, R.E. and Harrington, J.B. 1978. Forest fire history maps of Ontario. Can. For. Serv., Ottawa, Ont. Misc. Rep. FF-Y-6. 1 p. + maps.

Harrington, J.B., and Donnelly, R.E. 1978. Fire probabilities in Ontario's boreal forest. p. 1-4 *in* Preprint Vol., Fifth Joint Conference on Fire and Forest Meteorology. Sponsored by Am. Meteorol. Soc. and Soc. Am. For., 14-16 Mar. 1978, Atlantic City, N.J. [Abstr. publ. in Bull. Am. Meteorol. Soc. 58:1351]

Howe, C.D. 1915. The effect of repeated forest fires upon the reproduction of commercial species in Peterborough County, Ontario. p. 166-211 *in* Forest Protection in Canada: 1913-1914. Can. Comm. on Conserv., W. Briggs, Toronto, Ont. 317 p.

Penhallow, D.P. 1904. Notes on tertiary plants from Canada and the United States. Proc. and Transact. R. Soc. Can. 10(4): 57-76.

Richardson, A.H. 1929. Forestry in Ontario. Ont. Dep. For., Toronto, Ont. 73 p.

Rowe, J.S. 1972. Forest regions of Canada. Dep. Environ., Can. For. Serv., Ottawa, Ont. Publ. No. 1300. 172 p. + map.

Sharpe, J.R. and Brodie, J.A. 1931. The forest resources of Ontario, 1930. Ont. Dep. Lands For., For. Br., Toronto, Ont. 60 p. + charts and maps.

Smith, W.H.C. 1892. Report on the geology of Hunter's Island and adjacent country. Geol. Surv. Can. Annu. Rep. 1890-1891 (Part G) p. 1-76.

Stocks, B.J. and Hartley, G.R. 1979. Forest fire occurrence in Ontario. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. (map).

Terasmae, J. 1967. Postglacial chronology and forest history in the northern Lake Huron and Lake Superior regions. p. 45-58 *in* E.J. Cushing and H.E. Wright, Jr., *Ed.* Quatern. Paleoecol. Proc. VII Congr. Internatl. Assoc. Quatern. Res. Yale Univ. Press, New Haven, Conn. 433 p.

Turner, K.B. 1950. The relation of forest composition to the mortality of balsam fir, *Abies balsamea* (L.) Mill., caused by the spruce budworm, *Choristoneura fumiferana* (Clem.) in the Algoma Forest of Ontario. M.S.F. thesis, Univ. of Toronto, Toronto, Ont. 365 p. [condensed version available as: Dep. Agric. Publ. No. 895. 107 p. 1952].

Weaver, W.F. 1968. Crown surveys in Ontario. Ont. Dep. Lands For., Toronto, Ont. 25 p.

Woods, G.T. and Day, R.J. 1976. The present and past role of fire in Quetico Provincial Park. Ont. Min. Nat. Resour., Atikoken, Ont. Quetico Prov. Park Fire Ecol. Stud. Rep. No. 2, 9 p. + appendices and map.

Woods, G.T. and Day, R.J. 1977. A fire history study of Quetico Provincial Park. Ont. Min. Nat. Resour., Atikokan, Ont. Quetico Prov. Park Fire Ecol. Stud. Rep. No. 4, 17 p. + map.

REALITIES OF MANAGING FIRE IN ONTARIO

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Abstract.--Ontario's new forest fire management policy and centralized forest fire management organization are introduced, and fire and prescribed burn activities of the past 10 years are discussed briefly.

Five elements that affect forest fire management and its integration with land and resource management are discussed. First, fire is a natural element in the boreal forest, and cannot be excluded completely. Second, the demands and expectations of the public must be considered in fire management policy and programs. Third, while the demands for more and better services are increasing, financial constraints and inflation have diminished the ability of the fire organization to satisfy these demands, and the trend is expected to continue. Fourth, the application of technology has increased the effectiveness of the organization significantly, but it is only a partial solution to the problem of improving fire management. Fifth, measurable results are needed so that the effectiveness of the management program can be assessed. The efforts of the program must contribute to targets set by land and resource management clients.

To deal with these issues it is suggested that clients be more directly involved in the design, development and delivery of the program. In addition, fire management considerations must be more closely integrated with land and resource management. Planning is essential. Finally, research results must be utilized fully by managers.

Résumé.--On présente la nouvelle politique de gestion des incendies de forêt en Ontario ainsi que l'organisme chargé de la gestion centralisée des incendies de forêt, puis on discute brièvement des activités liées au feu et au brûlage dirigé réalisées au cours des 10 dernières années.

Il est question de cinq facteurs qui interviennent dans la gestion des incendies de forêt et son intégration à la gestion des terres et des ressources. Tout d'abord, le feu est un facteur naturel dans la forêt boréale et cette considération ne saurait être complètement mise de côté. Deuxièmement, la politique et les programmes de gestion des incendies doivent tenir compte des exigences et des attentes du public. Troisièmement, bien que les demandes de services supplémentaires et améliorés soient en augmentation, les contraintes financières et l'inflation ont réduit la capacité de satisfaction de ces demandes par l'administration et on s'attend à ce que cette tendance se poursuive. Quatrièmement, l'application de nouvelles techniques a accru considérablement l'efficacité de l'organisation, mais ce n'est qu'une solution partielle au problème que pose l'amélioration de la gestion des incendies. Enfin, il faut mesurer les résultats pour

évaluer l'efficacité du programme de gestion. Le programme doit contribuer aux objectifs de la clientèle de la gestion des terres et des ressources.

Pour toutes ces questions, il est proposé que les clients participent davantage à la conception, à l'élaboration et à la réalisation du programme. En outre, les questions reliées à la gestion des incendies doivent être intégrées plus étroitement à la gestion des terres et des ressources. La planification est essentielle. Finalement, les résultats des recherches doivent être pleinement utilisés par les gestionnaires.

Introduction

I shall begin with a brief review of Ontario's fire management policy and some of its implications. I shall then discuss centralized fire control and our methods of achieving fire management targets. Finally, and perhaps most important, I shall explore methods of improving our ability to deliver a sound fire management program and an integrated resource management program responsive to our clients' needs.

Background

I shall review Ontario's current fire management policy, touch briefly on centralized forest fire management, and highlight key features of our fire and prescribed burn program in recent years.

Fire Management Policy

Prior to 1981 Ontario's fire policy dictated that every fire within the intensive protection zone receive aggressive suppression action. Often this was expensive and impractical or impossible with current resources and technology. Since 1982, however, our policy has provided for a fire response dictated by values at risk and the cost of response. Let's examine some of the key elements of this new policy:

1) The recognition of two key realities: a) wildfires cannot be totally eliminated from Ontario's forests; therefore, fire management is based on protection of values and on cost-effective operations; b) forest fires are not confined to public lands; therefore, fire management is conditionally extended to all lands in the province that constitute a fire hazard, irrespective of land ownership or jurisdiction.

2) Fire has always been a significant factor in the forests of Ontario and will continue to have an impact on the people and their environment. Forest fire management is therefore an integral part of land and resource management.

3) Because forest fires do not respect judicial or adminstrative boundaries the responsibility for fire management in Ontario rests with the Minister of Natural Resources. This responsibility is subsequently assigned to municipalities, delegated through the Deputy Minister to the Ontario Ministry of Natural Resources (OMNR) field organization and is shared with those land and resource users who have a vested interest in protecting such resources. I want to draw your attention to the fact that this statement of responsibility does not imply any new relationship with organizations or people outside OMNR's fire organization that have an interest in fire control. It simply spells out the responsibility for fire management. Program delivery is still governed by the Forest Fire Prevention Act.

4) The policy states that fire management is a strategy of fire control and fire use practised in concert with land use objectives and conducted in a manner that considers environmental, social and economic criteria. In other words, fire management is not an afterthought, a task carried out only when there are flames in the forest and smoke in the sky.

5) The objectives of the program spelled out in the policy include preventing personal injury, loss of life and social disruption resulting from forest fires; minimizing the negative impact of fire on public works, private property and the natural resources of Ontario; and utilizing the natural benefits of fire in achieving OMNR's objectives for land and resource management. The important fact here is that this is not a "let-burn" policy. We are as aggressive as ever about protecting human life, private property, and natural resource values in Ontario. The fire control effort, however, will recognize the values at risk in each situation.

6) The fire management program provides expert knowledge and specialized services in matters of fire control and fire use to client groups within and outside OMNR. Values at risk are protected by attempting to prevent the occurrence of wildfire or by controlling those wildfires that do occur. Prescribed fire is also used as an approved resource management technique.

7) Every forest fire in Ontario receives a response, which is governed by the predicted behavior of the fire, its potential impact on people, property and values, and the estimated cost of the response. The response can be monitoring (passive) or aggressive control (active).

8) The whole program is designed within a comprehensive planning system and is implemented in accordance with area plans. These area plans outline fire management objectives for a given land base or fire management zone. Delivery plans describe the administrative procedures and operating guides necessary to accomplish the fire management objectives. In this process resource managers of all disciplines set the priorities for both fire control and fire use in their areas, to ensure that Ontario's high-value forest lands are protected. This approach recognizes that every hectare in Ontario cannot be protected equally--it just isn't economical.

9) This policy forms the framework for the integration of fire management with the rest of OMNR's resource management programs. It requires consultation with resource managers with respect to values at risk, and the type of fire response that could be expected should wildfire occur. It demands that we communicate effectively and often with our major cooperators (e.g., municipalities and the forest industry). It permits the matching of fire control and fire use needs to resource management requirements for protection and for fire use. It is intended to be "active" rather than "reactive".

10) The new policy also recognizes the importance of research and the application of research results. It states that the fire management program maintains its high standard of performance and continued delivery of a modern, efficient product by encouraging research to meet specific needs and by applying available technology. Meetings such as this symposium provide us with a valuable opportunity for furthering our aim.

This, then, is the essence of the new fire management policy that currently guides our actions. You as resource managers have a responsibility to know and understand its framework and its dictates.

Centralized Fire Control

The establishment of centralized fire control created considerable controversy within OMNR and among our clients. Centralized fire control is just an approach to delivering the required services to our clients in an effective manner with fewer resources, and to making better use of the skills available to us. The object is to provide a better response to fires and to reduce the number of fires that "escape". Where fires do escape, an immediate followup is required so that they can be contained if the values at risk warrant it.

Centralized fire control is not a means of separating the fire organization from the rest of OMNR's program. Good working relationships are more important than ever. Client needs must be clearly identified and priorities set so that these needs can be met. Resource managers and fire managers must work together to achieve this goal. The area planning process is the mechanism for accomplishing this. Needs are identified and the area prescriptions are developed to reflect priorities. The process also provides local area managers and clients with an opportunity to audit the results.

OMNR's fire organization still depends on assistance and support from other programs and from its major clients to deliver effectively the level of fire management program required. The woods industry is a major source of assistance, providing initial attack and support capability. Municipal fire brigades also form an integral part of the fire control capability in Ontario.

Current Situation

Over the past 10 years fires have had a serious impact on the forest lands of Ontario. In each of five of these years fire activity has been more severe than the average fire activity in any other year over any previous 10-year period. The average area burned per fire ranged from 136 ha to 323 ha for these five fire seasons. In 1974 there were more than 1,600 fires, in 1975 and 1976 more than 3,000, in 1977 more than 2,000, in 1981 more than 1,600, and in 1983 more than 2,200. Until the mid-1970s we could expect one serious fire year every 12 or 13 years. This cycle seems to have changed, however.

The characteristics of the severe fire years of the 1970s and early 1980s include periods of multiple fire starts, usually lightning-caused during periods of high fire danger; fire behavior that was difficult to control, as indicated by high intensity and rapidly spreading fires; and the resulting strain on fire suppression forces inside and outside OMNR's organization. Fire suppression forces belonging to OMNR, the forest industry, and the native communities of the province were engaged in long periods of difficult fire line operations.

The impact of these fire seasons varied, but negative results included the following:

- excessive suppression costs ($35 million in 1980)
- social disruption (evacuation - Red Lake/Summer Beaver, etc.)
- interruption of transportation (highways, airports)
- reduction in tourism
- disruption of supply and scheduling in the woods industry
- disruption of OMNR's other programs (e.g., silvicultural operations)
- private property losses

On the other side of the equation are the positive results, including enhanced wildlife habitat development, stand conversion in the old forest, and creation of age class diversity in recreational areas.

There are a number of reasons, both real and perceived, for this apparent change in fire history in Ontario. Some experts point to a change in climate. The suggestion is that the Northwestern Region is under the influence of a prairie lake climate, and that this has meant long periods of unusual drought. Fuel conditions are changing as well. More and more cutover areas are resulting in larger areas of slash fuels than in the past. The effect of spruce budworm infestations is also critical in many parts of the province. In addition, it has been suggested that our earlier policy of fire exclusion has resulted in abnormal accumulations of fuel in the standing forest that are ripe for ignition and major fire spread. More people than ever before are living, working and taking recreation in the forests of Ontario. Despite our best prevention efforts, the number of man-caused fires is increasing. Forest values and the investment of individuals and companies in the forest in general are increasing; hence, the impact of fire on these values can be much more severe than it was in the past. It has been suggested as well that an apparent reduction in our ability to deal with fire is the reason for more fires and larger areas burned in the past 10 years. Whatever the reason, these 10 years have been the busiest ever experienced by the program in terms of forest fire suppression.

Our prescribed fire program has continued to expand during the past 10 years despite the heavy fire load. At the present time we are burning over 6,000 ha annually. Of course, the most successful prescribed burning program is conducted in the area of the province of lowest wildfire activity. The competition for men and equipment in this area has been minimal. In Northeastern Ontario, prescribed fire is a treatment that is becoming more popular. However, prescriptions are becoming more precise and refined, so that there are fewer opportunities for conducting burns. In addition, costs are rising, and our budget is diminishing. Just how much more prescribed burning we can do with our current resource levels is uncertain.

The Realities of Fire Management

A modern fire management policy, an effective organization for delivering a fire management program, and the experience that we've had over the past 10 years are all very nice, but there are five factors we must take into consideration if we are to make progress in our fire management program and achieve integrated resource management in this province.

Ecological Factor: the Influence of Fire

Regardless of how modern or effective or well funded a fire suppression organization is, fires cannot be excluded completely from the boreal forest. Tim Lynham's paper, "History and the Natural Role of Fire in Ontario", points that out very clearly. It is technically impossible to prevent all fires. Lightning fires will be with us for the foreseeable future.

Fire control is becoming more expensive just like everything else. How much can we afford to exclude? How much can we afford to include? We as resource managers must strive for proper balance; we must make decisions that reflect the need for protection and understand the difference between areas that require aggressive fire suppression and areas that do not.

Social Factor: the Influence of People

The ultimate client for all government programs, of course, is the taxpayer. Public

scrutiny of our program is inevitable. Until recently this has been especially true of our land use planning exercises, our forest management program, our parks program, and to some extent the fish and wildlife program. More recently the public scrutiny has become an important issue in the fire management program. We must be more accountable to the public for what we do. For example, the Northwestern Ontario Area Chambers of Commerce at their annual meeting this fall were highly critical of OMNR'S fire organization and its apparent inability to deal with fire over the past decade. The issue here is not whether they are right or wrong but that they are interested in what we are doing and are publicly commenting on our ability to do our job.

The demands for protection are changing. Native communities are asking us to provide levels of protection in the areas north of Red Lake, Sioux Lookout and Geraldton similar to those we provide in the commercial forest area of the province.

These demands may be a result of the fact that the public does not have a good understanding of the complexities of fire management. For example, the apparent contradiction between fire prevention and the use of prescribed fire may be confusing; the public may prefer "fire exclusion" regardless of the economic or ecological consequences. It is up to us to communicate with the public and explain the logic of our program. While public interest and public involvement in fire management may be reasonably new to us, it is important that we as fire managers and resource managers be aware of public demands, expectations, and desires and that we keep them in mind when we are developing program policy and implementation strategies.

Economic Factor: the Influence of Money

I talked earlier about a new fire management policy that permits us to make decisions based on values at risk rather than forcing us to undertake a uniform, aggressive response to all fires. I want to emphasize the fact that human lives and private property continue to be the top priority for fire control operations. The only other value quantified to date is wood fiber. It has been suggested by some managers that if we look after these three values, the other values will automatically be taken care of. This may be desirable for us as fire managers in view of the difficulties we have in quantifying other resource management values in the forest.

Forest values are increasing. The message is clear. The viability of Ontario's forest industry and infrastructure in the short run depends on the old forest. This old forest requires protection and access from now until the new forest is available for harvest. Resources must be allocated for this purpose.

At the same time the increasing commitment of resources to forest renewal dictates a commensurate commitment to fire protection.

Constraints and inflation have eroded our traditional capability, even though $6.25 million was added to the basic fire management budget in 1981 and 1982. Our ability to acquire goods and services has decreased by $3 million and 75 man years in 1983 and 1984. These trends are expected to continue. A productivity curve has been developed that can predict the expected area burned on the basis of the amount spent on protection. The reduction of $3 million in buying power results in an increase in the expected area burned of approximately one-third to the current level of 135,000 ha annually. This curve is based on area burned. Later in this session you will hear from Charlie Van Wagner, Trevor Woods and John Osborn who will be presenting papers on the effect of fire on the forest. These presentations will deal with timber volume rather than area as a measure of the effect of fire on the forest resource.

Technical Factor: the Influence of Technology

We are already very good at what we do in fire control in Ontario. An examination of past fire seasons indicates that somewhere between 90 and 93% of all fires are successfully contained at initial attack and that the average fire size is less that 2 ha. We can probably improve our record by a few percentage points. However, large fires will continue to occur because of fuel conditions, severe fire weather and the over-commitment of suppression capability during periods of multiple fire occurrences. We have one of the most advanced fire management agencies in North America. Computers, precipitation radar, infrared, lightning locator systems and advanced telecommunication systems are all used on a daily basis in the fire management program. The application of this kind of technology has improved our ability to predict, detect, and respond to fires that do occur. We use modern equipment and trained personnel. Our initial attack force is based on five-man fire crews led by a qualified initial attack fire boss. He is supported in his operation by a fleet of

air tankers including CL-215s, cansos, twin otters, and helicopters. There is a nationwide movement to modernize the air attack capability of fire suppression agencies in Canada, and in Ontario's case there will be nine CL-215s at the end of this modernization period. Helicopters have become the primary vehicle for transporting crews from the base to the fire. This kind of utilization reduces response time and contributes significantly to effective initial attack operations.

Our in-service training programs are up to date, and are aimed at enhancing the skills and knowledge of people so that they can do their job more effectively. The very latest techniques are taught. In addition, technical schools and universities play an important role in educating and training students in resource management.

Nevertheless, technology can take us only so far. To date there have been no major breakthroughs that are likely to have a significant impact on our ability to improve the record in the near future. We can achieve better results by more efficient utilization of what we have. Centralized fire management is a step in this direction.

In addition, we are limited to some extent by the state of the art in other related disciplines. For example, we rely to a large extent on weather forecasts to predict the occurrence and behavior of fires. These predictions are used in deploying fire fighting forces and dispatching them to fires as they occur. Initial attack fire bosses use weather forecast information to predict fire behavior and to make plans for suppression operations on new and existing fires. Weather forecasting is not a precise science. Technological improvements in this area will also enhance our ability to make predictions.

Program Factor: the Influence of Results

The fire management program is in the business of providing fire suppression and prescribed burning services to a variety of clients. It is therefore a means to an end, not an end in itself. The measureable results of our program should reflect this. Our current system is inadequate in that it is more a measure of our failures than of our successes. We still report on fires fought, hectares burned, and values lost. We want to be able to report on fires prevented, hectares saved, and values protected. As a service program, we should be able to focus our efforts on helping resource managers to meet their targets, whether it be through fire suppression or prescribed burning.

The problem is that fire management is still viewed as an afterthought. Resource management planning often does not take into consideration the possible effects of its decisions on fire management. For example, it has been a corporate decision not to spray budworm-affected areas of the province. The effect of this decision has been an increased fuel hazard. The fire management organization was not a part of this decision. I am not suggesting that the decision would have been different had the fire management organization been involved; however, the future effects of this type of decision might have been better understood by resource managers and fire managers if there had been realistic fire management inputs. This increased fuel hazard will certainly affect our ability to control fires occurring in these areas. This in turn will affect any resource targets associated with these areas.

The land use planning process identified wood shortages as a problem, and large fires appeared to be one of the prime causes. The fire management organization was not actively involved in this process and hence was somewhat surprised at the final outcome. I don't want to suggest that this lack of involvement was somebody else's fault. In the past, the fire management organization has often been willing to sit back and provide a protection service only rather than becoming involved in resource management planning and land use planning processes. Resource managers must identify the values to be protected. Fire managers must attempt to provide the required level of protection. Our results should be a measure of our success.

Dealing with Reality

Now that we have discussed the five factors that must be considered in fire and resource management, I would like to discuss ways of dealing with them under three headings: public involvement, integrating fire and resource management, and the continued utilization of research results.

Public Involvement

Public interest in what we do in fire management will become more and more important to us. Although difficulties and frustrations will be inevitable, the public must be involved in the design, development and delivery of our programs. For the purposes of this discussion I have identified two kinds of public: that which is made up of individuals living in the province who have an interest in what we do and that which is made up of our

major clients like the woods industry and other major resource users in the province. The support of these two groups is critical to the successful development and implementation of a fire management program.

We must be able to communicate with them, educate them, help them understand the issues, complexities, and ramifications of a sound fire management program. Our message has to be consistent and credible. There must be a clear understanding of prescribed fire, fire prevention, and the burning of mature forest as a management technique as opposed to harvesting fiber in the case of wilderness parks. The rationale of the fire management program must be sound and logical so that it can be easily explained to the public. We must be able to understand the policy and its ramifications ourselves so that we can achieve consistency and credibility in our program.

We can learn from others who have involved the public in fire management decisions. The Northwest Territories developed a fire management policy for their area in the late 1970s, primarily to establish zones of protection in the territories. The protection level offered in these zones varied depending on values at risk and the cost of providing fire control services. The public was involved in this process, but when it was all over and the zones were finally determined there was considerable public dissatisfaction. There were two possible reasons for this dissatisfaction: either the people who were involved expected to get something out of the policy and planning exercise that did not materialize, or else they would have been unhappy whatever the results. I have used this example to illustrate that if the public does become more involved in fire management issues and the fire management program it may or may not be happy with the outcome. As resource managers and fire managers in OMNR we must be aware of this possibility when we invite public participation in the fire management program.

One of our major clients, the woods industry, has always been very interested in fire control and fire management programs in Ontario. This interest was highlighted after the 1980 fire season when the Ontario Forest Industries Association submitted a brief to the Minister of Natural Resources asking for more involvement and more participation in the fire control program in the province. This brief resulted in the establishment of a combined OMNR-forest industry committee to deal with the items raised in the brief. The outcome was a well planned industry involvement in the initial attack portion of the fire control program. Formal training programs were designed particularly for the woods industry people. Initial-attack fire boss and crew training packages were developed. The need was seen for a company fire plan that clearly spelled out company responsibilities for fire operations on their limits. Further participation by the forest industry and the fire management program was explored. Responsibility for the cost of fires caused accidentally as a result of forest operations, the use of forest industries as prime contractors to provide fire crews and other suppression resources, and the involvement of the forest industry in prescribed fire were explored. While there has been little to show for these discussions there are exciting possibilities for development in these areas in the future. David Dasti and Bob Bishop will expand on these possibilities a little later in the program.

Integrating Fire

Fire management must be integrated into land use and resource management planning. Staff attitudes will have to change, however. Fire staff will have to anticipate the consequences of their actions in developing and managing fire management systems. For example, restrictions on other operations such as scarification will have to be based on realistic, understandable criteria so that fire prevention requirements can be accommodated without unduly affecting site preparation targets. Resource managers must have a similar understanding of the consequences of their actions. For example, forest management plans must take into consideration the impact of fire on the depletion allowances in a particular management unit, and on the method and timing of forest renewal operations.

With respect to prescribed burning it is apparent that unit foresters must become more skilled in developing the use of fire as a site preparation tool. They must know more about the application of fire to a site. In general they are still more comfortable in using bulldozers and other forms of mechanical equipment for site preparation. Many clients are concerned that they may not be able to complete burns once they have planned them. It is important that the fire organization recognize this fact and demonstrate that prescribed burns can be carried out in a reliable manner.

On a broader scale, the area planning process as outlined in the fire management policy provides the mechanism for ensuring that resource management considerations are included in the overall fire management plan for an area. If these plans are properly

developed by using the skills and expertise of the resource managers and the fire management personnel who will be responsible for implementing them, we will have taken a major step towards integrating fire and resource management. In my view, the area planning process is the catalyst that will identify forest values at risk and prescribe the proper fire management treatment. The planning process will bring resource managers and fire managers together as a team to make the best possible use of our people, equipment and technology. It will also identify areas in which some fire will be inevitable, and at the same time prescribe ways of minimizing the negative impact of fire in these areas. There will be better identification, description and definition of client needs.

Other key resource managers and users outside OMNR must be brought into the development process. The forest management agreements that have been signed by many forest industries in Ontario place the onus for forest renewal on these companies. Fire management planning must involve these resource managers so that their needs can be clearly defined and fire management prescriptions for an area can take into account the values at risk.

Utilization of Research Results

Research programs are established to generate new knowledge and understanding and to develop new methods and techniques for practical application. It is the fire manager's responsibility to apply the results of research. In some situations the need for research has been identified, the research has been completed, and the results have been ignored. If we are to deal effectively with the realities of running a fire management program, we, the managers, must be able to define real research needs and use the results to improve our fire management operations. We must continue to support and foster research efforts, cooperate with researchers and share responsibility for the results.

Many of the presentations that follow will describe research projects. Those of us who are resource managers should use this opportunity to broaden our understanding in these areas. The displays and exhibits will also give us an opportunity to look at what others are doing, to discuss their work with them and to determine whether these new and/or different techniques might be of assistance to us in our own work.

Conclusion

The demands placed on resource managers seem to be increasing all the time. There are demands for increased recreational opportunities, demands for wood for the mills, demands from the public to be involved in resource management and land use decisions. At the same time our most optimistic expectations are that we will have the same budget next year as we had this year. Probably our budget will be reduced. Demands for protection of the forest from fire and the use of fire in managing the forest are increasing. I've made reference to the new interest of the public in our ability to manage fire. Progress and improvement in resource management and fire management will come from using our human and physical resources more effectively. As resource managers and fire managers we must work together to ensure that we achieve our resource management objectives.

DETERMINING FOREST VALUES AND STRATEGIC FIRE RESPONSES FOR THE NORTHWESTERN REGION OF ONTARIO

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Abstract.--As a starting point for an integrated fire management area planning process, the fire and forest management organizations of the Northwestern Region of the Ontario Ministry of Natural Resources produced a model display of forest values on five levels. The Region was then zoned to provide strategic protection level guides for deployment of resources, and three levels of dispatch requirements were prescribed in each zone.

Résumé.--Les organismes chargés des stratégies contre les incendies et de l'aménagement forestier de la région du Nord-Ouest du ministère des Richesses naturelles de l'Ontario ont construit une grille à cinq niveaux des valeurs attribuées aux forêts, comme point de départ à la planification intégrée des districts de défense contre l'incendie. La région a ensuite été zonée pour orienter le déploiement des ressources, selon le niveau de protection stratégique, et trois niveaux de coordination de la lutte ont été prescrits dans chaque zone.

During the 1970s it became apparent in the Northwestern Region of Ontario that wildfires were affecting significant portions of the productive forest land base. Table 1 illustrates a recent 10-year cycle of fire losses for the Red Lake District.

During this period it was the policy of the Ontario Ministry of Natural Resources (OMNR) that "all wildfires occurring within the fire regions and within the intensively protected areas of the province will be aggressively suppressed."[1] The intensively protected areas of the province during this period extended north to the 13th Baseline (lat. 52°, 30'). When the other main suppression characteristics of fire in the Northwestern Region were considered (multiple starts, high percentage of lightning-caused fires, isolated locations and limited equipment and manpower delivery), the need to establish priorities became apparent.

In the late 1970s this need was expressed at a district level but, because a statistically sound data base was lacking, because OMNR was committed to the land-use planning exercise, and because the provincial fire organization was being restructured, the idea remained in the proposal stage. During the winter of 1980-1981, after another severe fire season, a preliminary priorities map was pre-

[1] Revised policy AF 03.02.01 issued on 31 August 1980 by OMNR's Aviation and Fire Management Centre, Sault Ste. Marie, Ontario.

Table 1. Fire losses over 10 years in the Red Lake District, Northwestern Region, showing the source of ignition.

Year	Total no. of fires	Area burned (ha)	Source of ignition (%)		
			Man-caused	Lightning-caused	Unknown
1974	117	334,443	12	83	5
1975	52	132	6	94	0
1976	303	99,436	17	82	1
1977	76	146,950	3	97	--
1978	12	749	17	83	--
1979	147	1,301	6	91	3
1980	90	58,627	11	87	2
1981	73	20,197	35	64	1
1982	42	271	22	76	2
1983	191	224,375	13	87	--
Total/Avg	1,103	886,481	13	85	2

pared and presented to the District Manager, Red Lake, and the Regional Director, Northwestern Region, for their consideration. It divided the forest into eight categories mainly on the basis of the Forest Resource Inventory, with species and age class being the primary considerations.

At the same time (1980-1981) a province-wide data base was being established as part of OMNR's development of a corporate planning system and its commitment to the land-use planning exercise. The data base was designed to determine the location and quantity of resources available across the province. The exercise, therefore, would soon provide the necessary data base for demonstrating the role of fire in timber production.

In order to determine the potential land base for production forest and, eventually, to provide volume estimates for the province, two exercises were initiated in northern Ontario as part of OMNR's strategic land-use guidelines. On a district-by-district basis the initial exercise involved a determination of the potential land base that could be allocated to timber production. This was called the single factor timber target test, whereby deductions from the total inventoried area of each district were made for patent lands, roads and potential corridors, site class III sites (that percentage estimated by the district to be unable to sustain timber production), inoperable sites, sites permanently lost to fire, and "not satisfactorily regenerated" (NSR) lands. From this data base, district average working group and age class distributions, rotation ages and yields per hectare were used, and a preliminary estimate of annual area and volume availability was made for each district and region in the northern portion of the province.

It was agreed that other factors known to have an effect on a sustainable wood supply must be incorporated into the target test to provide a reliable supply estimate. This involved the "adding back" of volumes that would be obtained on a one-cut basis from roads and site class III sites as well as potential volume losses from fire, reserves and parks. This exercise was entitled the multi-factor timber target test.

Three approaches, using available information, were taken in testing the timber target with fire loss as a factor. In arriving at an estimate of volume losses as a result of fire, districts used either 10- or 20-year average fire loss statistics.

Figures from Red Lake District were used as an example, and the following estimates were made:

Method 1

If the average current annual increment (CAI) is used and it is assumed that the average annual fire loss on productive areas occurs over the average rotation period, the following volumes may be lost:

1.75 NM m^3/ha/yr x 18,358 ha/yr x 90 yr = 2,891,500 NM m^3/yr. (NM = net merchantable).

Method 2

A further refinement followed, whereby the district's forest was represented by its actual age class distribution and it was then assumed that annual fire loss could be applied representatively across the average age with each class. If the average CAI is multiplied a more reliable estimate of average volume loss is obtained:

$$\frac{\text{Age class}}{21\text{-}40} : \frac{\text{Annual fire loss}}{18{,}358 \text{ ha}} \times \frac{\text{Avg age}}{30} \times$$

$$\frac{\text{\% prod. forest}}{17} \times \frac{\text{CAI NM m}^3\text{/yr}}{1.75} = \frac{\text{est. volume loss NM m}^3}{163{,}845}$$

In the Red Lake District example, after distributing the losses representatively across all age classes, we arrived at a cumulated average of 1,954,053 NM m^3 per year.

The third method attempted to address the main concerns of the supply situation and industry. Here, only age classes of potential merchantability were considered. This method also introduced actual net merchantable volumes per hectare distributed by the age class factor and represented by actual site classes present in each district.

These volumes were then applied against areas of the jack pine *(Pinus banksiana* Lamb.) working group in the 41-60+ age class and areas of the spruce *(Picea* spp.) working group in the 81-100+ age class. Even when the fire loss statistics were restricted to the merchantable classes, the Red Lake District was still showing a net loss of 906,000 NM m^3, roughly equivalent to its present mill commitment and equal to 44% of its total sustainable annual allowable cut.

Note that, of the total district capability, only 50% is licensed for timber production. This creates a very large deficit when one deals only with active management units under license as opposed to unaccessed, unallocated areas to the north.

Sioux Lookout District experienced a similar situation, with an average loss of 37% of district capability and only about half under license.

The rest of the districts in the Region were faced with a very different problem. Their target or capability, before fire loss was applied, was already equal to their annual allowable cut and commitment to industry. With fire losses occurring at the following rates as a function of total capability--Kenora - 30%, Dryden - 28%, Ignace - 26%, Fort Frances - 10%--the Northwestern Region already had a projected deficit in wood supply to the year 2000.

Subsequent to these findings, recommendations were made and strategies were developed in the land use guidelines both to accommodate policy and/or initiate change, and to meet assigned targets. As a result, within the forest management section, the following recommendations were made:

1) to afford a higher degree of forest protection against fire, disease and insects;

2) to identify and protect high-value forest areas as a top priority in the restructuring of forest fire management strategy in Ontario.

Subsequently, it was recommended that the fire management program be conducted within a comprehensive planning system and implemented in accordance with area plans that prescribe the fire management objectives for the district. These objectives were spelled out as follows:

> "Fire management efforts in the Region will be directed towards maintaining and, where possible, reducing the amount of conifer volume loss on an annual basis. This will be accomplished in part by developing a system to priorize timber values so that higher priority areas are designated for a greater level of protection from fire, while lower priority areas are designated for an adequate level of protection."

Discussions about a new fire management policy continued, and the initial undertaking of providing a link between this and other land and resource management objectives was initiated.

In 1982-1983 communication continued between fire and other resource managers. The fire section of the Northwestern Region requested each district to provide a values map similar to the 1981 Red Lake effort. These ranged from maps identifying property values to detailed timber project maps, and on the whole were considered inadequate for planning purposes.

Later the fire management improvement project initiated all-program seminars for the Northwestern and North Central regions of the province to introduce other program super-

visors and district managers to the new fire policy and the direction being provided through the fire management improvement program, and to solicit feedback on ways and means of integrating other values (i.e., fish, wildlife, lands, timber, etc.) into the area planning exercise.

As a result of these years of continued communication, the Northwestern Region formed the Forest Area Planning Subcommittee on 1 January 1984. Its mandate was to provide the regional management committee with a package of forest resource values for integration into the area planning exercise in the 1984 fire season. It consisted of forest representatives from each district of the Northwestern Region.

After our initial deliberations it became apparent that we had a consensus. We agreed that the timber values system should be simple, with as few levels as possible, and that it should be easily recorded and compatible with present fire management mapping systems. We felt that district-to-district variations should not be a significant factor. All the allocated wood was required by the mills, and therefore, we should consider only areas currently under licence. Our initial recommendations were forwarded to the major companies in the Region who provided us with some favorable feedback.

We decided to set up a computer-compatible recording system that will permit flexibility so that any other present or future values can be incorporated into the forest domain (Table 2). Our system allows for the establishment of the initial priority level on a quarter base map level, i.e. approx. 6,000 ha, with quick referencing in the computer, and the most detailed description at the fire block level, i.e., 350 ha. A sample description of forest values and color code follows.

RED 1 Tree improvement program areas and annual plan areas including camps, cut wood, etc.

YELLOW 2 5-year allocations or operating plan areas.

BLUE 3 Management planning areas, i.e., 20-year allocations.

GREEN 4 It was agreed that this category would encompass a variety of objectives all related to the management plan. These would include variations in species, site, age class distribution, etc. The remaining area would be in category 5. At the same time it would allow for district-to-district and company-to-company variations.

WHITE 5 This could range from areas of inaccessible, overmature forest in excess of management requirements, to untreated cutovers, areas of disease infestation, NSR 3, 4 and 5, etc.

Table 2 gives an example of the computerized recording system used.

The next step in the process was to look at the resultant array of forest values and determine if the aggregations could be used to define substantial zones of highest and lowest values.

A multi-program task group reviewed the historic processes of determining protection levels in the Region. These were referred to earlier as an intensive protection zone and an extensive protection zone, roughly divided at 52° 30' north latitude.

In view of the display of current and projected values for forests, it was recommended that a first line of defence could be struck along the northern boundary of licensed or committed timber areas.

This produced an area that would be considered first priority for protection and would have first claim on available fire fighting resources. It was identified as the intensive protection zone (I.P.).

The area north of this line was determined to be the second priority. It was identified as the extensive protection zone (E.P.). During discussions, the factors regarding current wood supply status were reviewed and from them a determination was made that a third transitional area would be required to provide an immediate offset capability to any unavoidable large-scale wood losses in the licensed areas.

The Forest Values Subcommittee was given the task of determining the extent and boundaries of this area. In their final submission they included mature as well as maturing forest values in the area that should receive a better protection level whenever and wherever possible. This area was identified as the modified intensive protection zone (M.I.P.).

The next step was to look at non-forest values, i.e., private structures, urban and suburban development, industrial sites, cottages, etc., and determine their specific location. These areas were designated total protection zones. It was found that the former district fire centers had a very com-

Table 2. Timber values data 1984.

Base map	Base map rating	Regions NW	NE	SW	SE	Forest management unit	Remarks
506933	T4			T4		Pakwash	predominantly immature timber (40-80 years)
	T5	T5	T5	T5	T5	Great Lakes	wood young and generally mixed; no significant timber concerns
	T1	T1	T1			crown	annual plan areas being harvested in blocks 4, 14
		T1	T1	T1	T1	Pakwash	harvesting and regeneration operations regional logging camp in blocks 17, 27
	T5					Great Lakes	no timber concerns
506934	T1	T1	T1	T4	T1	Pakwash	harvesting and silvicultural operations (NW,NE,SE); overmature timber white spruce - immature, inaccessible block 77-Querel's Camp block 54-Lecot's Camp
	T2		T2			crown	NE in 1986 operating plan; block 0 has potential allocations
506941	T1	T1	T1	T4	T4	Pakwash	harvesting and silvicultural operations within operating plan NW and SW - S. Pakwash Road being constructed NE and SE - immature, access by S. Pakwash
506942	T3	T4	T1	T3	T4	Pakwash	NE - annual harvesting operations SW - overmature to be harvested in new operations NW - majority in Woodland Caribou Park mature in blocks 74-77 SE immature, access by S. Pakwash

prehensive inventory of these and could provide a ready reference in time for obtaining an accelerated response. The main fire detection systems are similarly keyed to immediate identification of such values, so a unified regional inventory was not developed in the first analysis and remains to be done and integrated into a regional plan.

Similarly, fire risk or occurrence was reviewed and it was generally concluded that the highest risk occurs in the urban/suburban areas of the Region and along the major highway/railway rights-of-way. This risk, however, is generally a daily or seasonal projection and was not incorporated intitially in the plan. It, too, awaits further work.

Other values of a less obvious nature require further study. Undeveloped park reserves, future cottage or recreation development sites, and areas in which the flora and fauna are sensitive to environmental changes or to disruption by man all need to be catalogued and fitted into the future strategy.

For the fire season of 1984, then, we had a first evaluation of forests, a comprehensive inventory of small-site forest and non-forest values and an overall strategic priority statement by zone.

The third and final item was to develop fire response descriptions to guide the fire management system in the determination of fire resources and their deployment in areas of greatest need, and to assist in setting priorities between distinctive fire events should the need arise. The task group developed the strategic response guidelines as displayed in Figure 2. It set forth for each protection zone a series of responses expected on the basis of the values in the area of the fire occurrences.

The system has within it some benchmarks according to which, if a fire escapes initial control efforts, the resource manager(s) must be consulted prior to reducing or abandoning further control efforts.

The system was reviewed before the Regional Management Committee and the Executive Management Committee, and endorsed for trial in 1984. Strategic response guidelines for the Northwestern Region for 1984 are outlined below.

1. Total Protection Zones

- areas of permanent urban or suburban industrial development around which any fire has a potential to do significant damage
- all fires to be suppressed at a minimum size
- prescribed fire not a permitted management tool
- prevention of man-caused fires to be a major activity.

All responses to be automatic air and ground attack.

2. Intensive Protection Zones

- areas of present or immediate future resource development or extraction, tourism centers, pioneer industrial development around which fire has a potential to damage the area's resources now or in the immediate future
- man-caused fires to be prevented
- all fires to be suppressed at a minimum size
- prescribed fire to be used to preclude future fires, as a burnout, or where resource management needs are well described
- engineering for hazard management to be pursued.

Levels of strategic response to fires within the total and intensive protection zones

Responses to fires threatening human life and/or investment, or forest values 1 and 2 will be made on the basis of:

- automatic dispatch of closest air attack
- automatic dispatch of closest helicopter attack with a level 5/5 fire crew
- alerting of closest air attack and fire attack resources for immediate backup dispatch
- preparation and alerting of a minimum Fire Boss 3 for backup response or fire takeover
- continuous aggressive followup until fire is put out.

Responses to fires threatening areas with forest values rated 3, 4 or 5 or areas identified as undeveloped, sensitive areas within district land use guidelines.

- dispatch of closest appropriate air attack where indicated or requested
- dispatch of closest helicopter attack or ground attack resources
- preparation and alerting of a minimum Fire Boss 3 for backup response or fire takeover
- preparation and alerting of appropriate contingent air attack and fire attack resources for immediate response if requested
- continuous aggressive followup until fire is put out.

3. Modified Intensive Protection Zones

- areas of future resource development, small communities or offset areas for resource management, tourism outposts, pioneer industrial development around which fire may restrict the potential use of the area
- risk of man-caused fires minimal
- fires to be suppressed at minimum size with available resources
- area manager decision on escaped fires as to continued aggressive followup, containment or monitoring only
- area manager decision on reduction or withdrawal of initial attack deployment.

Levels of strategic response to fires within the modified intensive protection zone

Responses to fires threatening human life or investment will be made on the basis of:

- automatic dispatch of closest air attack
- automatic dispatch of closest helicopter attack with a level 5/5 fire crew
- alerting of closest air attack and fire attack resources for immediate backup dispatch
- preparation and alerting of a minimum Fire Boss 3 for backup response for fire takeover
- continuous aggressive followup of the fire attack until fire is put out.

Responses to fires threatening forest values rated 4 or 5

- dispatch of closest appropriate air attack where indicated or requested
- dispatch of closest ground attack resources via best transport means available to pursue initial attack and followup until fire is put out
- preparation and alerting of a minimum Fire Boss 3 for backup response or escaped fire analysis and recommendation
- alerting of area manager for briefing and decision on followup of escaped fires.

4. Extensive Protection Zones

- areas of limited or minimal resource or tourism development, small native communities, airstrips and communication facilities scattered throughout
- man-caused fires associated with community areas in the spring
- fires may have a negative effect by impinging on native communities or on areas associated with possible native development options
- option of using burnout as a containment tactic
- lightning major cause of fires.

Levels of strategic response to fires within the extensive protection zone

Responses to fires threatening human life or investment will be made on the basis of:

- automatic dispatch of closest air attack
- automatic dispatch of closest level 5/5 fire crew
- alerting of closest air attack and fire attack resources for immediate backup dispatch
- preparation and alerting of a minimum Fire Boss 3 for backup response or fire takeover
- continuous aggressive followup of the fire attack until fire is put out.

Fires within areas immediately surrounding communities but not threatening life or property, including forest value 4 areas:

- dispatch of qualified fire boss by air transport with initial attack suppression unit
- assessment and decision on initial attack using local residents.

All Other Fires in the Area

- dispatch of qualified fire boss to prepare escape fire analysis and recommendation
- periodic monitoring of fire perimeter and update escaped fire analysis.

The future work on this process will consist of further data collection and evaluation, and identification of protection areas within the larger zones for which specific protection prescriptions can be prepared, setting out relationships and efforts in each fire management program area (i.e., prevention, detection, suppression, prescribed burning, etc.).

This program is continuing in the Region until completed.

FIRE PREVENTION AND FOREST OPERATIONS

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Abstract.--Hazards connected with fiber extraction jeopardize the aesthetic and economic value of our forests. This paper focuses on cooperative efforts between the Ontario Ministry of Natural Resources and industry to prevent fires on valuable forest lands. A program begun in 1980 includes operational guidelines based on fire danger ratings, clarification of respective responsibilities in fire prevention, training programs, fire planning, better enforcement and educational techniques. These efforts must be maintained at a constant level: it is not enough to react to fire on an ad hoc basis.

Résumé--L'extraction du bois menace les valeurs esthétique et économique de nos forêts. La présente communication porte sur les efforts du ministère des Richesses naturelles de l'Ontario et de l'industrie en vue d'empêcher les incendies sur les terres forestières de la province. Depuis 1980, un programme tire parti, à cette fin, de lignes directrices opérationnelles fondées sur les méthodes d'évaluation du risque d'incendie, la définition des responsabilités respectives en matière de prévention des incendies, de programmes de formation, la planification de la défense contre les incendies, la mise en vigueur améliorée des règlements et des techniques d'éducation. Ces efforts doivent être constants: il ne suffit pas de riposter aux incendies quand ils se déclarent.

An Industry Perspective

Introduction

I would like to begin by defining the objectives of the forest industry with respect to forest fire prevention. I believe there are three principal objectives:

1) practising fire prevention, i.e., doing everything possible to prevent fires from starting;

2) presuppression, i.e., equipping ourselves to suppress fires that occur on or near our work areas;

3) providing backup (i.e., lessening the impact when the Ontario Ministry of Natural Resources (OMNR) is involved in a problem fire or has a heavy fire load).

This impact is what really concerns us. With today's demand for wood fiber, and the scarcity of desired fiber, we simply cannot afford significant losses of wood fiber to fire. It is a matter of survival as far as the industry is concerned, and consequently, we must place a high priority on fire prevention.

The relationship between the forest industry and fire is not new. Loggers and the

various fire control agencies have been rubbing shoulders for years. Of particular interest, however, is the fact that there has been a pattern to their relationship.

In 1849 a Royal Commission was set up in Ontario to study the protection of forests from unnecessary fire. The first fire prevention legislation followed in 1878, but it was not until 1886 that any action was taken. In this year the first fire rangers were appointed. Costs were shared equally by government and timber operations...two dollars a day, plus travelling expenses!

The years passed. From 1895 to 1900, large fires burned township after township of forested land in northeastern Ontario. If there was concern there was little action; after all, the forests were limitless--one could always move to another patch of wood.

This acceptance of fire would change, however; three tragic fires followed: the Baudette Rainy River fire of 1910, the Porcupine fire of 1911, and Canada's worst recorded fire, the Matheson fire of 1916. Collectively these fires obliterated several communities; over 338 lives were lost and hundreds of thousands of hectares of forest were blackened.

These catastrophic events led to a number of developments in forest fire prevention. In 1917 the Ontario Forest Fire Prevention Act was passed. Permanent fire rangers were hired and a field organization was developed, ranger stations and warehouses were built, a lookout tower program was started and some mechanized equipment was acquired. These improvements were funded by a 2.5¢ per hectare charge levied on all timber licencees.

Following the Haileybury fire of 1922, in which 18 townships were burned and 43 people perished, fire prevention efforts were increased. The Provincial Air Service was organized in 1924 and began operations with 19 World War I flying boats.

There were no other significant fires until 1938, when the Fort Frances fire burned 40,000 ha and killed 17 people. Concern about the losses incurred in this fire was probably a key factor in the formation of the Ontario Forest Industries Association (OFIA) in 1943. Fire protection was one of the highest priorities of these early industrialists. However, they found many of their efforts for reform of the Forest Fire Prevention Act to be ineffective, and it took the 1948 Mississagi fire to change this. The destruction of 200,000 ha of prime timber virtually wiped out the white pine industry in the Blind River area.

This fire had a tremendous impact. The shock was felt throughout government and industry alike. The OFIA formed a special committee, reviewed the problem, and submitted a brief to the Department of Lands and Forests. This brief was constructively critical of both industry and government, and without doubt was instrumental in bringing about improvements in forest protection procedures. It also ushered in a new era of cooperation and development. Company fire marshalls were appointed, fire equipment was purchased, and forest industry workers were heavily involved in fighting the Chapleau fires of 1955.

Continued efforts of the OFIA were productive. In 1957-1958 short fire courses were given to industry people by Lands and Forests. In 1959, Section 12.4 of the Forest Fire Prevention Act was amended; operators were no longer required to prove their innocence with respect to fires originating in their work areas. This amendment ended 13 years of lobbying on the issue. Of equal importance was the agreement on the part of Lands and Forests to pay woods operators for their services in fire fighting.

This spirit of cooperation prevailed through the 1950s and up to the mid-1960s. However, for a number of reasons, it declined in the late 1960s and early 1970s--partly, perhaps, because there were relatively few fires with a major impact during this period. Nevertheless, fire control technology and overall fire control organization in Lands and Forests were improved. Industry was finding the costs of fire equipment and of dedicating labor to fire fighting too high. These increased costs, together with the reorganization of Lands and Forests as the Ministry of Natural Resources in 1973, paved the way for industry to turn over the job of fire fighting to the provincial government. Although concerns were raised in 1974, 1976 and 1977, as these were heavy fire years, it was not until 1980, when fires such as Kenora 23, Ignace 27 and Thunder Bay 46 burned a total of 274,000 ha of licensed land and an estimated $2.4 billion was lost to the economy, that industry was jolted back into reality. It was the end of another era of acceptance.

Another OFIA fire committee was formed and in December of 1980 a brief containing 12 proposals was submitted to the Ontario Cabinet. This brief made two major recommendations:

1) that funds should be set aside for purchasing 15-20 large amphibious water-bombing aircraft, as Ontario's water-bombing fleet was not adequate;

2) that the forest industry as a whole must become involved again in forest fire protection.

Progress Since 1980

In response to recommendation 1), five medium-to-heavy water bombers have been added to the provincial fleet: three Twin Otters and two CL-215s. Two more CL-215s are scheduled to be added to the fleet in 1986, and five in 1988.

In response to recommendation 2), a number of major steps have been taken.

1) Companies have been authorized to take action on fires that occur in their immediate work areas. Initially OMNR was reluctant to accept participation by industry in some areas, but this reluctance seems to be fading, and industry fire fighters are being accepted as part of the team. Industry is taking action on some 64 fires annually.

2) A joint OMNR-OFIA training program is under way. To date, some 124 industry fire-crew instructors have been trained, 95 initial-attack fire bosses have been qualified, and more than 2,200 woodsworkers have been certified as fire crewmen. It should be noted that certified industry crewmen are now paid the same straight time rate as OMNR fire crewmen for fire duty. Since 1983 a formal scheme whereby OMNR audits industry crews has been jointly accepted. I have been involved personally in this training program, and have found it a pleasure to work with our crews. As a group they are sincere about fire training, they are mature, and they are bush-oriented. Given half a chance, they will be as good at fire fighting as they are at cutting wood.

3) Fire plans are now a condition of the work permit approval. These must be submitted to and approved by the local OMNR district before the start of the fire season. The general consensus is that they are very worthwhile--they are in essence an agreement as to how the total fire problem will be handled in a particular area.

4) Significant amounts over and above annual charges are spent annually by industry on fire equipment, training and fire prevention. From a survey we conducted of most OFIA member industries we concluded that this is in excess of $630,000 and that collectively the companies have on their work sites more than 300 power pumps, 207,000 metres of fire hose, 1,900 pack pumps, and 2,200 axes and shovels. Other specialized equipment includes ground tankers and even some helicopters with buckets. In addition, $240,000 is spent on equipment and structural fire protection; for example, the industry owns over 5,800 fire extinguishers.

5) Communications and general fire awareness have improved. Most companies have annual fire meetings with their local OMNR district staff before the fire season. Daily telex exchanges between the various OMNR fire attack bases and company offices about fire occurrence, fire weather indices and predicted weather are commonplace. Currently, industry has approval to use OMNR provincial fire frequencies on hand-held radios. We believe that this approval should be extended to include direct emergency radio links between OMNR fire attack bases and remote company offices.

Conclusion

In conclusion, I think it's fair to say that we have made real progress, and relations between the industry and OMNR with respect to fire fighting are good. It would be foolhardy, however, to say that all our problems are solved, or that everything in the last four years has been a bouquet of roses. There have been some trials and tribulations, as is normal in any relationship.

As for the future, there are several issues that require attention. One that has not been properly addressed in the past is the issue of forest closures, along with the closely related operational guidelines. Although we are not opposed to the basic concept of closure in certain circumstances, we have a number of concerns. The forest industry is the first user of the forest to be affected whenever the fire danger becomes very high. The general public, also a prime user and a traditionally high "fire starter", is seldom put under any restriction except for occasional temporary limitations on campfires after forestry operations have been ordered closed. Travel restrictions on the public are thought to be extreme measures, and are rarely enforced. We believe that local travel by the public, for example, in immediate work areas, can and should be restricted when industry operations are restricted. All user groups must share in fire prevention, even if this means short-term sacrifices in some cases.

A number of questions arise about operational guidelines during closure. To my know-

ledge, there are several procedures in use or under proposal, but industry has had little opportunity for input. It is my belief that this situation should be rectified, as operational guidelines affect us directly. Are these guidelines really in tune with modern-day logging? Are they too protective and consequently too restrictive?

Many logging operations have gone to full-tree harvesting, with delimbing at roadside. Our OFIA survey indicated that approximately 42% of the area harvested is handled this way. In consequence, cutover slash has been drastically reduced, and therefore the volume, arrangement and dispersal of one of the most hazardous fuel types have been changed. Accelerated scarification often follows quickly upon the heels of harvesting, altering what is left on the site. Are the fire indices really representative of the specific work area? Indices computed from weather stations 30 to 50 km away can, on any given day, be totally inaccurate for a specific work site.

No consideration has been given to increased prevention and presuppression efforts. Surely a properly equipped and trained crew that is on site and at the ready lessens the risk.

Mechanization of the logging industry may present problems as well. With the increase in mechanization there will be a reduction in employees in the bush, and therefore in times of emergency there will be less manpower to draw on. Because less machinery is doing more, and the investment in such machinery is considerable, industry will become more reluctant to shut down or to release operators to fight fires or participate in fire training. On the other hand, only time will tell if fewer but more complex machines will reduce or increase fire risk.

A concern of those of us who operate east of White River is the shift of unit crews to the west. In 1984 three unit crews were relocated in the west. Further movement is planned for 1985 or 1986, and we understand that five crews are scheduled for relocation at that time. In addition, there has been a reduction in key permanent fire staff because of financial constraints, and reorganization in the form of "centralized fire control" has taken place. Although the intent is to be more efficient, to do more with less and to place resources where fires are most frequent, in fact this reorganization has resulted in fewer resources, and they are going to be missed when they are most needed. Under normal circumstances the reduction in fire staff will not be noticed, but under heavy fire loads it will. In the case of a sudden outbreak there will be a time lag before resources can shift east, and I can assure you that the east can and will burn.

In addition, we must accept the fact that our area charges have been increased and will probably be increased by an additional 50%. This hardly seems fair.

My final concerns are personal, but after all, certain privileges should be accorded a speaker.

I will call my first concern "incentives". The fact that some companies spend more than others and give higher priority to fire prevention should not matter; after all, who benefits? Unfortunately, the rewards of fire prevention, or any kind of prevention program, are often very difficult to assess in dollars and cents. Nevertheless, shareholders and boards of directors are inclined to assess all programs in such terms. It may be difficult to justify substantial expenditures for an aggressive fire prevention program.

In the case of automobile or fire insurance--and really, a fire prevention program is a form of insurance--good clients or responsible clients receive a better premium rate, i.e., an incentive to be responsible. Such an incentive demonstrates to good clients the rewards of being good, and encourages bad clients to become more responsible. In the case of forest fire prevention, who would be the overall winners if we were all good clients?

My final concern--and I have been saving it because I feel that it is the most important of all--is the durability of our cooperative relationship with OMNR in the area of fire control. Over the years we have come together as a result of one crisis or another and then drifted apart for awhile until another crisis occurred. At the moment we are cooperating. Let's not drift apart, because we cannot afford another crisis.

An OMNR Perspective

Introduction

How many times have we heard that the effectiveness of a forest fire prevention program cannot be measured? This may be partially true, but if we can assume that a forest user who is totally unaware and uneducated about fire is a high fire risk, surely the sensible thing to do is to introduce a fire prevention program in an attempt to increase

his awareness and knowledge. We can assume that the user will be less of a fire risk following exposure to the program, and that the program has therefore been effective. Perhaps this effectiveness can even be measured in some quantitative way as an increment in knowledge.

This is the assumption upon which OMNR, in its fire prevention program, bases its attempts to increase awareness and knowledge among specific groups of forest users so as to reduce the number of significant man-caused forest fires.

"Significant man-caused fires" are those that have a negative impact on public works, private property, and the natural resources of Ontario. Nowhere is fire more likely to have such a major impact than in the forest industry. From 1980 to 1983, 209 industrial fires burned over 140,000 ha in Ontario. Many more fires on licensed areas are caused by recreational users, OMNR activities or activities of other industries, and these have burned as many hectares again.

Recently, several important steps have been undertaken in an attempt to reduce the impact of fire on licensed lands. Some of these Bob Bishop has already described to you --company fire plans, operating guidelines, additional fire suppression resources, increased dialogue between OMNR and the industry in an attempt to identify problems, and fire suppression and fire prevention training programs. In addition, OMNR has reorganized its fire control system on a centralized basis and has strengthened fire suppression and fire prevention activities at the regional level. It has also established a new fire management policy in recognition of the fact that, while it has overall responsibility for forest fire management, there are other sectors of society that have a vested interest in protecting and enhancing forest values and resources, and therefore ought to share this responsibility.

These developments stem from an increased awareness on the part of both OMNR and OFIA member companies that cooperation is essential in the area of fire protection, and that a number of issues must be addressed if we are to reap the full benefits of our natural resources.

While forest fire prevention seems to be a part of these new cooperative efforts between OMNR and industry, I sometimes think that it has been more often addressed in boardroom sessions on both sides than in sessions designed specifically to increase the effectiveness of individual programs.

Recent fire prevention surveys conducted by a well established polling firm reveal that, in general, people believe that the prevention of forest fires is an individual responsibility, and that every individual has it within his capacity to guarantee that he is not the cause of a forest fire. It is our mandate to give these individuals the tools--the education, the engineering techniques, and the reminders--to do that job.

The responsibility for carrying out forest fire prevention activities must be reassigned from the corporate level to the operational and even individual level so that company fire prevention programs are not perceived to consist solely of the purchase of pumps and hoses. Companies must develop a philosophy that governs individual activities and is as much a part of their operations as is safety or productivity. In the same light, fire prevention responsibilities within OMNR should not be delegated to the prevention specialist, but should be part of the philosophy and understanding of everyone--from the duty officer to the fire operations manager, from the lands technician to the unit forester.

This approach can and must apply to OFIA members and non-OFIA members alike. While there is a substantial difference in the ability of each company to supply and maintain forest fire suppression equipment and resources, there is little difference in each one's ability to prevent fires from starting.

The time is right to develop such a philosophy, which is supported by key research findings indicating that forest fires do have a considerable impact on the health of the forest industry. How can we develop this philosophy and deliver it to the operations people who have the ability to prevent forest fires? We must investigate, we must communicate, and we must educate.

Investigation

First we must take a look at our existing programs to identify what is being done and what still needs to be done to meet the fire protection requirements of the forest industry.

One basic item requiring review is the Forest Fire Prevention Act itself. This act contains a number of regulations that pertain to the woods industry, some of them illogical and unenforceable and, consequently, openly ignored. We must review regulations governing spark arresters, smoking procedures, numbers of trained fire fighters, and so on.

The work permit, which by law must be issued before an operation begins, states the amount and type of forest fire suppression equipment required on a site. This permit was designed for an era when woods operations were labor-intensive. Today, even with high-production machinery, the number of axes, shovels and pails required is still related to the number of men on site, and may not reflect real requirements.

The criteria and procedures for work permit inspections often vary from district to district. A review of the purpose and benefits of this process should lead to the development of a more standard inspection procedure.

Guidelines that recommend hours of work and fire safety procedures for woods operations have been developed by OMNR and are in use in most regions of Ontario. While this is a sound concept, the management system governing its use is not well developed. The forest industry has not been a party to the development of these guidelines and has encountered many unforeseen problems in their use. The impacts of union agreements, of shiftwork schedules, of different types of operations such as piecework versus hourly rated work, are not fully appreciated by OMNR staff and had not been fully investigated prior to implementation of guidelines. There is little flexibility in the guidelines to allow different operations within the same company to be treated differently, even if their level of risk is different. Similarly, there is little opportunity to implement the schedules on an area basis rather than on a district basis. While there is a definite need to schedule high-risk forest operations so as to take into account the fire danger, a more intensive, cooperative management scheme must be explored to ensure that the medicine does not have more undesirable effects than the illness.

The investigation and reporting of all forest fires must be upgraded in both organizations. People refuse to accept the fact that a small forest fire is in fact a forest fire. Many fires occurring either on machinery or in forest fuels are quickly extinguished and therefore are not reported. The ignition potential of a piece of machinery or a type of forest operation, whether damage is done or not, is an important input into the company's and OMNR's fire prevention programs. They must be investigated and reported if they are to form part of the data base for fire occurrence prediction and for analysis of fire prevention programs required.

Analysis of fire causes by responsible group and source of ignition is the basis for determining the nature and extent of prevention programs required. There is little confidence in the accuracy of the existing data on industry-caused forest fires, and this lack of confidence is reflected in the quality of prevention programs aimed directly at the forest industry. It is also reflected in the degree of acceptance by the industry of many OMNR prevention initiatives. A cooperative effort by field staff on both sides is needed to upgrade the data and develop, implement and enforce programs that have a measure of credibility.

Fires caused by scarification operations have become increasingly common in recent years. Fifty known scarification-caused fires were identified in Ontario during the 1980-1983 fire seasons. Many more were started and not reported. Preliminary research into the exact cause of these fires has identified sources of ignition that range from discarded cigarettes, to sparks caused by drags in contact with rocks, to the prime mover itself. With companies assuming more and more responsibility for forest regeneration and site preparation it is imperative to review existing knowledge and research so as to be aware of potential ignition sources and reduce the number of fires resulting from these operations.

Though not directly related to prevention, recent changes that gear the rate of workman's compensation payments to the accident rate of employees should be investigated. Company fire crews injured on fire duty, which is not their regular job, are now subject to higher rates even after they return to their regular duties. Because of the increased costs involved, companies may be reluctant to offer assistance to OMNR suppression forces.

Companies must review the degree to which they have accepted their share of the job of making each and every operation fire safe. They must investigate the extent and quality of their fire safety rules and the extent to which their fire plans address the implementation and enforcement of these rules.

Communication

Once we have investigated our programs and identified our needs we must be able to communicate those needs to others with a common interest. A continuing dialogue between OMNR and industry is essential.

Fire prevention material developed to address the industry fire problem must be in tune with and in response to needs identified. In 1984 OMNR produced an industry-related prevention commercial designed for use in a major

television campaign. Questions such as "Who is the prime target audience?", "What is the most important message?", "What time is it best delivered?", and "What is the anticipated reaction?" are best answered through discussion and input from the forest industry. A formal system is required that develops inter- and intra-company communications so that information can be exchanged and common interests can be expressed in meetings with OMNR.

While the training and use of industry fire crews have increased Ontario's ability to make initial and extended attacks on fires, OMNR should not be attempting to use outside agency fire control resources in what is essentially its own job. Probably one of the most significant advantages of having trained fire suppression crews on company payrolls is that these crews can play an important role in communicating the fire prevention philosophy to the operations people.

The forest fire warden program must be resurrected and assigned the job it was originally intended to do on company limits. This is an essential link between OMNR and the forest industry. Individuals must be chosen with care and given adequate training so that education, engineering and enforcement components of the prevention program are perceived to be delivered cooperatively, not imposed unilaterally.

Joint inspection of work permit conditions should be standard practice so as to take advantage of the personal contact that this procedure offers. Followup inspections are just as important as initial contact, and should be standard practice as well.

Education

Probably the biggest challenge is to discover more effective ways of educating forest workers and the general public in fire prevention techniques.

Virtually all mechanical equipment used on site in a forest operation is a potential fire risk, because of the fuels used, the heat that develops, the design features, and the working environment. Those who are responsible for these areas could be educated and motivated to eliminate or reduce the risks that these machines present. They range from equipment designers to purchasers, from operators to those who enforce the operating and maintenance procedures. Forest fire prevention education programs should extend to all these people to ensure that the proper philosophy is developed at all levels of the organization.

Encouragement of a prevention philosophy through education has its greatest impact over the long term. Regenerated lands may present less of a hazard in the future if fire prevention is an integral part of the planting philosophy. Fire prevention expenditures could be more easily justified and could compete better with short-term expenditures like those on road building or fire suppression equipment if the long-term benefits were more readily understood and accepted.

OMNR's education program should lend support to the industry's efforts to protect its limits by publicizing these efforts and by ensuring that members of the general public who use the forest for pleasure realize that they are subject to the same strict rules as the man who draws his livelihood from the forest.

The risks of on-site welding and of smoking while working in areas that present a fire hazard, as well as ways in which these risks may be lessened or eliminated, are all targets for educational programs. With a good educational program in effect and logical and enforceable laws as backup, both OMNR and the industry can concentrate on strengthening the enforcement program.

If one were asked to identify a desired result of new prevention measures, one might cite the achievement of the same level of public awareness that is currently enjoyed by accident safety programs. Safety programs have behind them the philosophy that accidents mean lost productivity, high accident rates mean higher compensation payments, unsafe operations expose staff to the wrath of labor inspectors and to the powerful legislation they can bring to bear, and a highly effective education and communication strategy will create an awareness that is the key to prevention.

For the fire prevention program to achieve what the accident prevention program has achieved it must have up-to-date and enforceable fire laws that are based on extensive and sound research into the number of fires, their causes and their impacts; a strong cooperative enforcement presence on the job site; some direct short-term benefits from practising good fire prevention measures; and some structured mechanism for increasing and then maintaining the level of awareness and knowledge of fire prevention needs and techniques.

These goals are not easily achieved, but I sense a renewed desire within OMNR and an understanding by forest users of why we should work towards eliminating significant man-caused forest fires.

FIRE, HARVESTING, AND TIMBER SUPPLY

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Abstract.--Two questions about fire management are perennially raised: How does forest fire affect timber supply, and how can the value of fire control activity be judged? The answer to the first is that the effect of fire on timber supply should be analyzed on the basis of the whole forest, not from data taken on the burned area alone. The answer to the second follows on the first. Fire management must be considered an integral part of forest management, and the analysis should be based on the principle of "maximized net return" from the whole forest rather than on "net value change" on the burned area alone. Simple models and hypothetical results are presented. The scale problem is addressed.

Résumé.--Quand il est question d'incendies et de feux, deux questions reviennent constamment: comment les incendies de forêt influent-ils sur l'approvisionnement en bois et comment peut-on évaluer la lutte contre l'incendie? La réponse est que l'effet des incendies sur l'approvisionnement devrait être analysé sur l'ensemble de la forêt, et non pas au moyen de données se rattachant à la seule superficie brûlée. La réponse à la seconde découle de la réponse à la première. La lutte contre le feu doit être considérée comme faisant partie intégrante de l'aménagement forestier; l'analyse doit se fonder sur le principe du rapport net maximisé pour l'ensemble de la forêt plutôt que sur la modification nette de la valeur de la superficie brûlée seulement. On présente des modèles simples et des résultats hypothétiques. On traite aussi du problème d'échelle.

Everyone in the fire business is constantly aware that forest fire causes timber loss. In a severe fire season, terms like "huge", "catastrophic", and "disastrous" are heard on all sides. Every year the Canadian Forestry Service collects fire statistics from the provinces and territories, compiling information on burned areas in several categories. In 1980, remembered well as a record year in Ontario, the total burned area included 223,240 ha containing merchantable timber. At a conservative 100 m^3/ha, the killed timber would total some 20 million m^3, about equal to a year's roundwood production in Ontario. Does that mean that somehow or other the province had 20 million m^3 less wood to harvest? If so, within what time span? True, the current 10-year average of merchantable forest area burned annually in Ontario is only 25% of the 1980 values, but the same questions arise. What exactly do such losses mean?

Surely the forest is not just a mine, so that whenever some volume is lost or wasted, there is that much less available in the future. Perhaps, then, the whole standing forest could be pictured as a bank account, the annual harvest representing the interest. In that case, any deduction from the principal would simply result in proportionately less interest (if we assume, as well, that the rate of interest remains the same). No doubt, if trees were dollars, that is how it would be. Depletion by fire could be subtracted from the total inventory, and the allowable cut adjusted downward in proportion. Such a concept may

provide some rationale for interpreting the loss in the immediate sense but it still does not help us decide how long to maintain the reduced harvesting rate. Should it then be maintained until the amount of the lost principal, namely the original fire-killed timber, has been accounted for? If not, then what did that original so-called fire loss mean anyway?

Clearly, a forest is a far more complex entity than a bank account. Trees are not like dollars, and a cubic metre of wood in a 20-year-old forest is not the same as a cubic metre of wood in a 100-year-old forest. Nor is the forest simply divisible into areas labelled "merchantable", "immature", and "regeneration". In forest management circles everywhere, concern for projecting realistic, sustainable, annual allowable cuts (AAC) is increasing. Sophisticated models are available for evaluating all possible treatments and alternatives in silviculture and harvesting. In its natural state, however, most of Ontario's forest is cycled and renewed by random periodic fire, and has been for ages. The process is ecologically normal and, in spite of efficient control operations, the areas burned are often as large as those harvested. Should we not then apply the same cool logic to the effect of fire on timber supply that we give to the harvesting process itself?

Since a satisfactory answer to this question cannot be found in the traditional concept of "fire losses", let us shift our focus away from the burned area alone. Let us interpret the dynamics of the forest as a whole under the impact of both fire and harvesting. The proper goal is to incorporate forest fire realistically into modern timber supply analysis; this means projecting the effects of future fires as well as simply tracking the results of current depletions.

A good place to start is the concept of age-class distribution (ACD), which, together with the yield curve of volume over age, is the very foundation of forest management. Everyone is quite familiar with the classical, perfectly regulated forest, with equal proportions in every age class, each stand being cut as it reaches the rotation age. Not so familiar is the age-class distribution generally found in natural forests exposed to periodic random fire. There the basic form is the negative exponential ACD, with gradually decreasing proportions in each successive age class and a long-drawn-out old-age tail (Van Wagner 1978). These two contrasting ACDs, compared side by side in Figure 1, provide the principal clue to the nature of timber supply in forests affected by both harvest and fire. In other words, both fire and harvesting recycle

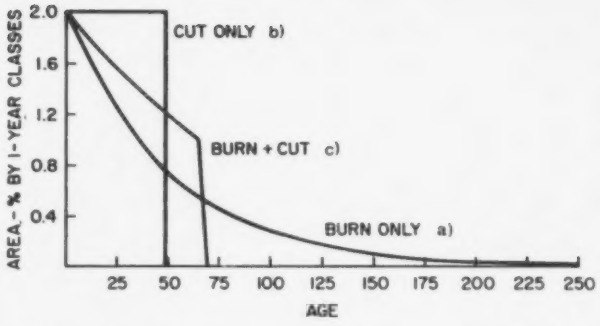

Figure 1. Age-class distribution of model forest for cases of a) 2% annual fire, b) 2% annual harvest, c) 1% fire plus 1% harvest.

the forest, but in quite different ways. How, in fact, can these two opposing effects be reconciled in one joint analysis? How much timber is available in a forest affected by both fire and harvesting?

At Petawawa, we have designed a basic simulation model to answer this question (Van Wagner 1983). The operator must state the annual proportions of forested area that are expected to be harvested and burned, as well as the yield curve and initial ACD of the forest. The model then runs by two simple rules: 1) fire strikes at random at any age, and 2) the stand of highest volume is always cut. Each run, if continued long enough at the given rates of burning and harvesting, yields an equilibrium value for the sustainable annual harvest volume. Through the use of a yield curve like that for black spruce in western Quebec, some 50 runs of the model were made and analyzed. Let us look at some of the principles that emerge. All volumes are quoted in terms of m^3/ha of whole forest, not just cutover area.

First, the long-term equilibrium annual allowable cut (AAC) decreases in a regular fashion as the average annual burned area (ABA) increases (Fig. 2). Note, for instance, that when ABA equals 1.0%, the AAC is still 70% of its maximum no-fire value. But such an average level of fire activity would quickly produce some of the extremes noted at the beginning of this paper. Even with the marked increase in Ontario's annual burned areas during the past decade, the average for 1974 to 1983 is still only 0.36% of the total protected area. At that burning rate, in a forest like the one modelled, even the complete elimination of fire would provide only an additional 10% of AAC. This curve, for the forest in question, is the essence of the model's results.

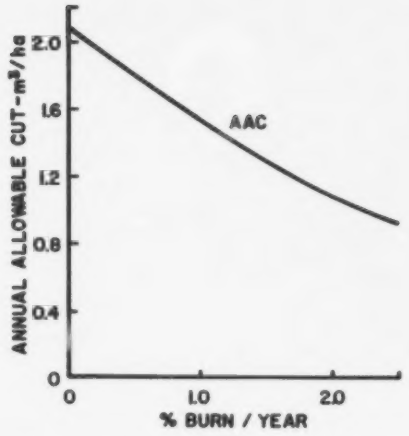

Figure 2. Annual allowable cut over percentage of area burned annually in model forest similar to black spruce forest in western Quebec.

Second, the annual volume of fire-killed timber is less than the corresponding depression in the AAC (Fig. 3). By this yardstick, the conventional fire loss is actually underestimating the steady drain on the sustainable harvest.

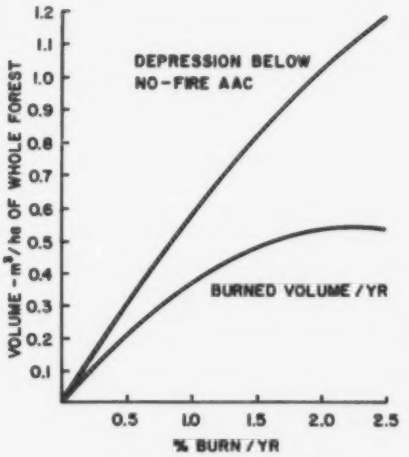

Figure 3. Depression of the theoretical AAC compared with volume of timber killed by fire annually, each plotted against annual percentage of area burned.

Third, the above points hold only when the forest is being operated for its optimum AAC at the given level of annual fire. Suppose that for some reason, whether ecological or economic, somewhat less than the forest's AAC is being harvested. The model then shows that the annual harvest is relatively insensitive to the amount of fire. Figure 4 is a set of curves of annual harvest volume over ABA for several levels of percentage of area cut annually. Note that the model forest yields its maximum of 2.1 m^3/ha when cut at 1.5% of area per year, and that the effect of fire in reducing harvest volume is strongest at this cutting level. As the cutting level decreases, the effect of fire on harvest volume diminishes. For example, when only half the optimum area is cut annually (say 0.7%), the forest will still yield 60% of the maximum possible harvest and will do so regardless of the amount of fire up to any practicable limit (say 1.0% annually). In other words, a substantial amount of timber is available from any forest no matter what its annual burning rate.

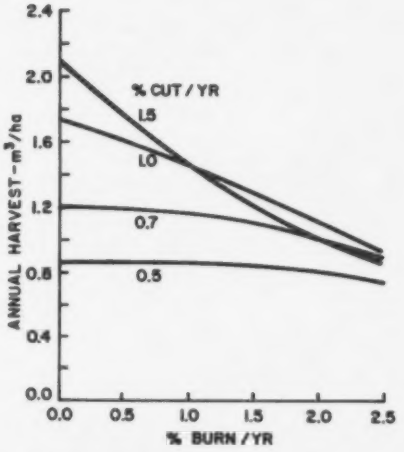

Figure 4. Available annual harvest over area burned annually for several levels of area harvested annually.

These are only a few of the issues on which this simple simulation model sheds light. I draw two main conclusions. One is that it is very difficult to visualize beforehand the combined effects of these two contrasting forces; when their joint dynamics are analyzed in a rational manner, the results do not necessarily jibe with conventional wisdom. The other, and main conclusion, is that the place to look for the effect of fire on timber supply is in the whole forest, not just in the burned area. The volume of timber killed by fire, no matter how carefully measured, is in fact a red herring; it will not supply the desired answer.

Of course, anyone could quickly list many factors complicating the simple picture outlined above. Access and logistics have obviously been ignored. However, three other factors are worth discussing here.

First, random fire implies equal flammability at all ages. But conventional wisdom has it that the susceptibility of a forest to fire increases with age. In fact it is hard to find data to support this notion. Coniferous forests are, in the physical sense, very flammable indeed at a young-to-moderate age. Then there is the evidence of the landscape itself, which provides many examples of roughly negative-exponential age-class distribution over wide areas. This factor supports the argument that constant flammability with age is indeed a reasonable assumption. Nevertheless, any known relation between age and tendency to burn is readily incorporated into such a model.

Second, the equilibrium timber supply is presumed to be of crucial importance over the long term. However, few present-day forests exhibit anything like their optimum age-class distributions. Of immediate interest, usually, is the trend of timber supply during a transition period, perhaps several decades, while the forest approaches regulation. Simulation lends itself easily to this problem, simply by using the present ACD as the starting point. The available timber volume is provided at any desired time interval, always with the effect of random fire imposed on the current forest as it changes shape toward an equilibrium state.

Third, all results discussed so far have been under a regime of constant annual burned area. To answer the obvious question, some runs with variable ABA were carried out. The first test is based on a random list of annual burned areas varying between 0.1 and 2.0%, while averaging 1.0%. No matter what the cutting level, such a variation in burned area from year to year has only a slight effect on the annual available timber volume. The entire range of annual harvests is contained within ±5% of the general average. The annual timber supply varies within a much smaller proportional range than the annual burned area. In other words, the anticipated future effects of individual fire years so overlap and interlock that the timber is supplied in a nearly steady stream. Even the above range of ABA (namely 20:1), however, is not very remarkable; it is in fact the approximate range in the national total. Ontario, for instance, has experienced a 200:1 range in provincial burned area in the past 15 years alone; obviously, the smaller the area at large, the greater the potential range in ABA. What would be the effect on timber supply if a really large proportion of the forest burned in one year? Figure 5 shows the effects of several such single "catastrophic" years, tested against a background of no fire at all before and after the year in question. The considerable delay, decades in this case, before the anticipated reduction in harvest is at its extreme is obvious.

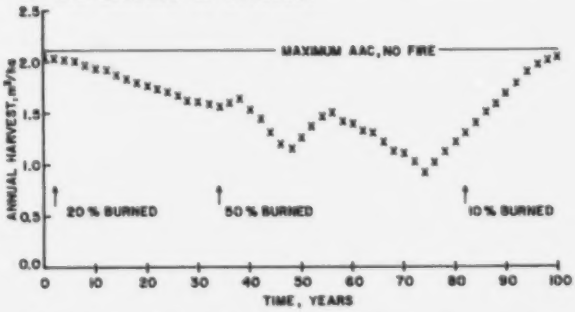

Figure 5. Effect of single extreme fire years on anticipated future timber supply.

The effect of variable ABA is thus really another major question in disguise, namely the question of scale. How large a forest fits the concept being discussed? Is it the whole province, a region, a district, or perhaps the working circle of a pulp mill? On reflection, the first test of scale is the "substitutability" of timber throughout the area in question. If harvest plans are interrupted, is the required timber available somewhere else in this forest? But, instantly, the issue of variability in ABA is raised: the smaller the area the greater the potential annual variation in burned area. Clearly, the crucial question is: "What is the biggest perturbation in timber supply that can be tolerated and what is its probability?" Set up in this way, such a simulation model could provide some answers about the size of the management unit that can be treated safely as a single entity. At the extreme lower limit of size, when a forest operation cannot survive the largest fire likely to occur in the prevailing forest type, the timber supply can no longer be viewed as described here. The problem becomes more one of insurance than anything else.

Having come this far on the subject of timber supply alone, we can easily take one more step and at least touch on the matter of economics (see Van Wagner 1985). Provided that this treatment of timber supply is valid in the most basic sense, then the analyses of sufficient protection and economic impact of fire follow almost automatically.

First, the traditional concept of "least cost plus loss", which has dominated the economic study of forest fire since its beginnings, turns out to be more of a hindrance than a help. The reason is that there is no bank account representing total forest value from which calculated decreases in value on burned areas can be subtracted to represent economic loss. The only thing worth valuing from the protection viewpoint is the harvest, which comes from the whole forest and is not directly related to what happens on burned areas. The appropriate governing principle is, instead, "maximized net return", a concept that has no doubt guided human enterprise since economic consciousness first appeared. Two curves, each in terms of economic value over average annual area burned, illustrate this principle and its application. One is of harvest value, the other of protection cost (Fig. 6). Clearly, for a sensible solution,

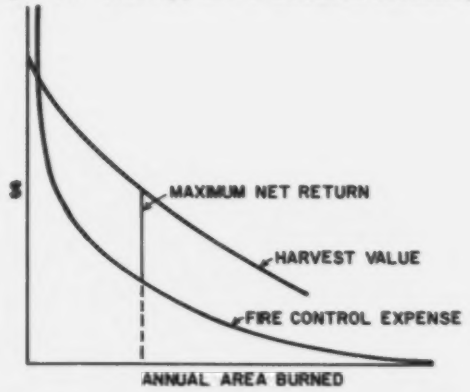

Figure 6. Maximum net return as the maximum difference between harvest value and cost of fire control, each plotted over area burned annually. Scales not quantified.

the harvest curve must lie above the cost curve over much of its length. The maximum net return is then found where the two curves have equal slope. At this point, the marginal cost of further reduction in burned area just equals the value of the corresponding increase in harvest value.

What, then, happens to the old concept of "fire loss"? Is it the value of the reduction in potential annual allowable cut? Or is it the cost of fire control operations? And does it include the cost of substitution when imminent harvest plans are interrupted by fire? As previously seen, the reduction in AAC below the no-fire maximum is actually greater than the volume of fire-killed timber. But is this a fair measure? If loss were defined as "economically available increased harvest", there would, in the state of "maximized net return", be no loss. The simplest way out of this confusion is to stop thinking in terms of loss at all. If we think instead in terms of "maximized net return", the pieces fall neatly into place.

Whenever a realistic economic analysis of fire management is made, however, the result may very well turn out to be an anticlimax, because of the difficulty of assigning a unit value to the annual harvest. Who will provide the proper value--the government stumpage accountant, the company woods manager, the sales manager, or the social economist? The answers range easily over two orders of magnitude. A tentative conclusion is that the economic impact of fire is, at its core, a rather "soft" issue. No government agency is obliged to change its ways on the basis of a straight economic analysis; besides, social and environmental concerns may weigh just as heavily when one is determining what to do about forest fire.

The timber supply aspect of the impact of fire is, by contrast, a very "hard" issue indeed. Only the coolest of logic will suffice, it seems to me, when one is analyzing the impact of fire on the lifeblood of the forest industry, namely its timber supply. The clear message from this analysis is that the correct measure of the impact of fire is not the fire-killed timber, but rather the reduction in potential annual harvest. And the correct answer can only be worked out by the rational analysis of forest dynamics.

The key word in the theme of this symposium is "integration", a term I have been saving until the end of this paper, in the hope that there it will have its maximum impact. My conclusion is that the logical analysis of the impact of fire in forestry leads inexorably into resource management as a whole. Any attempt to deal with forest fire as a thing apart is bound to fail.

Finally, it is also clear that the moment attention is shifted away from the burned area alone to the forest as a whole, the appropriate economic concept becomes "maximized net return" rather than "least cost-plus-loss". Both in the matter of timber supply and in the matter of economic impact, the key word is now integration. The business of forest management is to produce the maximum useful annual harvest; the business of fire management is the protection of that annual harvest.

Literature Cited

Van Wagner, C.E. 1978. Age-class distribution and the forest fire cycle. Can. J. For. Res. 8(2):220-227.

Van Wagner, C.E. 1983. Simulating the effect of forest fire on long-term annual timber supply. Can. J. For. Res. 13(3):451-457.

Van Wagner, C.E. 1985. The economic impact of forest fire. Paper delivered at Annual Meeting of Intermountain Fire Council, Banff, Alta., 25-27 Oct. 1983. *(in press)*.

A FIRE DEPLETION INVENTORY SYSTEM AND ITS APPLICATION IN FOREST AND FIRE MANAGEMENT

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Abstract.--An improved method for estimating wood-fiber depletions caused by forest fires has been developed by the Forest Management Information Section and the Aviation and Fire Management Centre of the Ontario Ministry of Natural Resources. The system provides estimates of depletions expressed in volume and area of forest losses for forest site classes, base maps/townships, forest management units, districts, regions and the province as a whole. It is in the early stages of development, but already has operational value. This paper describes the system, presents results from the 1983 fire season, and discusses some applications of the data in forest and fire management.

Résumé.--La Forest Management Information Section et l'Aviation and Fire Management Centre du ministère des Richesses naturelles de l'Ontario ont amélioré une méthode d'estimation des ponctions de fibre ligneuse par les incendies de forêt. On peut ainsi estimer le volume des ponctions et les superficies forestières touchées, selon les classes de stations, les cartes de base et les townships, les unités d'aménagement forestier, les districts, les régions et l'ensemble de la province. Le système en est à ses débuts, mais il trouve déjà une utilité. La communication le décrit, présente les résultats obtenus pour la saison des incendies 1983 et renferme une discussion de certaines applications des données en aménagement forestier et dans la lutte contre les incendies.

Introduction

A new system for documenting wood fiber depletion caused by forest fire in Ontario has been jointly developed by the Aviation and Fire Management Centre and the Forest Resources Group of the Ontario Ministry of Natural Resources (OMNR). This new system describes fire depletions in forested areas in terms of volume and area for working groups, age classes, and forest site classes for a variety of management areas. The results of this new system will enable fire and forest managers to define fire depletions jointly in standard and meaningful terms so that fire impact can be accurately assessed and fire management objectives can be more appropriately evaluated against actual results of fire impact. The fire depletion system has been under development for the past year and a half at the Aviation and Fire Management Centre. The system was tested during the 1983 forest fire season. This paper describes the fire depletion system in its current form, high-

lights the results of the 1983 forest fire season, and discusses the applications in both the forest management and the fire management programs.

System Description

The fire depletion records system has been designed to:

1) provide fire management with statistics on wood fiber losses by forest management area, district, region, and province in terms of gross total volume and area by age class and site class in a timely and consistent fashion;

2) provide a data base on fire depletions that can be amalgamated into a forest management data base and used to assess fire impact on wood supply on a short- and long-term basis at both the field and main office levels;

3) utilize the existing forest resources inventory data base but be capable of adjusting to changes to the operations of the forest resources inventory data base and overall forest depletion system that may result from changes in technology and management;

4) become part of the fire records system and historical fire information data base;

5) be incorporated into the forest management and resource management data bases in OMNR at both the main office and field levels, and nationally as part of the statistical data base.

The fire depletion system utilizes the forest resource inventory (FRI) as its source of forest information. The FRI data base is accessed by fire depletion computer programs from the Aviation and Fire Management Centre. The process requires user input at the field level to define burned areas accurately on FRI map sheets. These data are then processed, forest stand data are isolated from FRI data tapes and depletion statistics are produced and distributed.

Forest Resources Inventory Data

The FRI is the principal data base for forest management planning in the province. The fire depletion system also uses this data base as its principal source of forest data.

The forest stand is the basic recording unit in the FRI system. Forest stand data are recorded in two ways: on FRI base maps or township maps, and on a data file stored on magnetic tape in the Queen's Park computer branch. These data are subsequently processed by forest managers who produce various reports or ledgers on stand data, volumes, summaries by base map, management unit, district, etc. (Anon. 1978). The fire depletion system has been designed to utilize both the FRI map and the FRI data file containing the FRI stand data.

FRI map sheets are typically scaled at 1:15840 or 1:12500 for either a base map area or a township area. Forest stands are identified in polygons and numbered sequentially on each map sheet. Each stand polygon contains coded information pertaining to species composition, age, height, stocking, site class, and area. The units are either imperial or metric depending on when the FRI map was compiled. The FRI map also identifies protection forest (PF) and protection forest reserve (PFR) by the coded identifier. Nonforested areas are identified as rock, muskeg, swamp, agriculture, etc., by means of the 900 series identification system. Water area is also identified by the 900 identification system. There are approximately 500 stands on each map sheet. The FRI system in Ontario currently consists of approximately 5,500 map sheets covering approximately 66% of the province, excluding only the nonproductive areas in the far northern sections of the province (Fig. 1).

Figure 1. The forest resource inventory system in Ontario.

The data file of FRI data consists of 80 character records. Each record is subdivided into 13 fields. These fields code the forest district, management unit, township or base map number, ownership, working group, year cruised, stand number, stand area, species composition, stand age, stand height, site class, and stocking.

The fire depletion system has been designed to document stand numbers on the FRI map sheets that have been destroyed by fire and then to isolate the corresponding stand data on the FRI magnetic tape. Fire depletion statistics are then calculated and produced in report form and on data files.

Fire Depletion Inventory Sampling Criteria

During the past 10 years the province of Ontario experienced an average of approximately 2,000 fires annually. However, not all these fires caused appreciable forest depletion. In fact, over 90% did not cause any significant damage, either because they were kept under control or because fire conditions prevented spread. A study of the historical fire records revealed that 99.5% of the total area burned by fire in Ontario was burned by 3.2% of the fires and that these fires were 40 ha in area or larger[1]. On the basis of these results the system requires that all fires over 40 ha be inventoried.

The area within the province in which fire depletion is calculated is determined by the FRI coverage as shown in Figure 1.

Fire Depletion Data Collection

Mapping the Fire

If a fire is 40 ha or larger and is within the FRI zone, the fire perimeter is mapped on an FRI map. Green areas inside the burn perimeter are also mapped and identified on the FRI map sheet so that they can be excluded from fire depletion calculations.

Recording FRI Stand Data

A fire depletion inventory form is used to record FRI stand information. It is completed on a base map/township basis for the entire fire. It records information on management unit, Forest Management Agreement (FMA) holder (if any), name of licencee, fire number, and year. However, its main purpose is to record the number of each stand that has been damaged by fire. The percentage of area damaged for each stand number is recorded as 25, 50, 75, or 100%. Forest change information (e.g., new cuts or old burns) is recorded for each respective out-of-date stand number. The completed form along with the fire map on the FRI map sheet is forwarded to the Aviation and Fire Management Centre for processing shortly after the fire has occurred.

Data Processing

The data recorded on the fire depletion form are keyed into an intermediate computer program at the Aviation and Fire Management Centre. A data file is then created and transferred to the OMNR Computing Branch in Toronto where it is matched up to the FRI data files. Each stand on each base map that has been identified as being depleted on the stand depletion file is isolated on the FRI data file and the corresponding stand records are transferred to a separate file. Stand ages are updated to reflect current ages rather than ages at the time of inventory. Gross total volumes (in m^3) are calculated for each forest stand by means of the normal yield table volume equations for 1984 supplied by OMNR's Timber Sales Branch. The complete fire depletion data file is then organized and sorted to generate a series of data files and reports.

Depletions are expressed in gross total volumes (m^3) and area (ha). Area is determined from the sum of the areas assigned to each forest stand. Ages are categorized as: barren and scattered, 1-20, 21-40, 41-60, 61-80, 81-100, 101-120, and 121+ years. The site classes are 1 to 4. Site class x forest is included in site class 1. Volume data are not available for the barren and scattered age-class nor for site class 4 forest. Depletions in these two categories are expressed in area only. There is no separation by ownership at this time and depletions of area designated as being in the 900 coded series have not been tabulated as a system output.

The system currently produces 14 reports organizing depletion data by fire number, base map, management unit, region and province. The following is a description of each report.

The reports are produced at the end of the forest fire season both in hard copy and on data files on tape. The hard copy reports are collated and distributed as fire depletion statistics to fire management and forest management offices at all levels. Data files on

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[1] Callaghan, B.P. 1983. A new fire impact inventory system. Ont. Min. Nat. Resour., Aviation and Fire Mgt. Centre, Sault Ste. Marie, Ont. Intern. Rep. 9 p.

magnetic tape are available to users on request. These reports are currently in draft form and can easily be modified depending on user needs.

1983 Results

The fire depletion system was tested during the 1983 fire season. The following results typify the overall results of the system.

During the 1983 forest fire season 30 fires, each 40 ha or larger, occurred within the province's FRI zone. These fires ranged in size from 48 ha to 85,000 ha. There were 20 fires in the Northwestern Region, four in the North Central Region, three in the Northern Region, one in the Northeastern Region, one in the Eastern Region and one in the Algonquin Region (Table 1). A total of 15 districts had fires that were candidate fires for the fire depletion system. Four fires were not included in the 1983 results. The first was Fort Frances No. 10, which was 500 ha in grass and muskeg; the burned area was coded in the 900 series on the FRI map sheet. The second was Chapleau No. 5, at 248 ha. This fire burned production forest; however, FRI data were not available. The third was Minden No. 3 at 42 ha; FRI data were not available on the computer system. The fourth fire was Tweed No. 49 at 44 ha; again, FRI data were not available.

Table 1. Fire impact inventory system: 1983 candidate fires.

District	Number of candidate fires
Dryden	3
Kenora	1
Red Lake	11
Sioux Lookout	4
Fort Frances[a]	1
Northwestern Region	20
Geraldton	1
Thunder Bay	1
Nipigon	1
Terrace Bay	1
North Central Region	4
Cochrane	1
Chapleau[a]	1
Gogama	1
Northern Region	3
Blind River	1
North Bay[a]	1
Northeastern Region	2
Minden[a]	1
Algonquin Region	1
Tweed[a]	1
Eastern Region	1
Provincial total	31

[a] denotes those fires that were not included in the 1983 fire depletion statistics

The fire depletion inventory system showed that a total of 14.44 million m^3 of wood on production forest land were destroyed by fire in Ontario during 1983. This means that, of the total volume of 4.26 billion m^3 of wood on production forest area in the province[2], fire depleted 0.33% of the total volume of wood on inventory in Ontario. The largest depletions occurred in the jack pine (*Pinus banksiana* Lamb.) working group (6.8 million m^3). Losses in the spruce (*Picea* spp.) working group totaled 5.1 million m^3. The losses in these two working groups accounted for 11.9 million m^3 or 83% of the total volume depleted. Figure 2 shows that the largest loss occurred in the 81-100 age class group, and losses in forest classed from 61 to 120 years old were 12.9 million m^3 or 80% of the total volume lost.

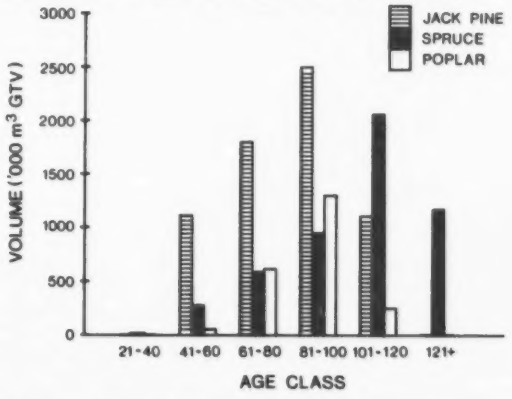

Figure 2. Ontario forest fire depletions - 1983 - losses by species and age class.

The three largest fires occurred in the Northwestern Region, two in Red Lake District and one in Kenora District (Fig. 3). Kenora fire No. 73 depleted 6.69 million m^3 of wood on

[2] J. E. Osborn, Forest Management Information Section Supervisor, Timber Sales Branch, Ont. Min. Nat. Resour., Toronto, Ont., 1984 (pers. comm.).

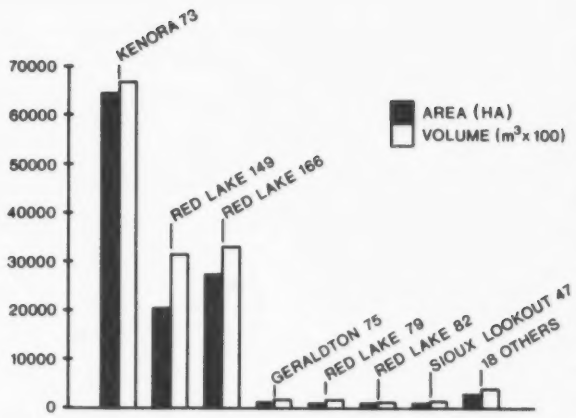

Figure 3. Ontario forest fire depletions - 1983 - losses by fire number.

64,558 ha. Approximately 3.46 million m^3 (51%) were on site class 3 sites and 2.43 million m^3 (36%) were on site class 2 sites. Depletion on site class 4 sites amounted to 16,743 ha (Table 2).

In total, the Northwestern Region lost 14.1 million m^3 of wood on production forest, or 98% of the total 1983 depletion in the province. Depletion in the North Central, Northern, and Northeastern Regions accounted for the remaining 2%. The distribution of losses within working groups in the Northwestern Region is similar to the provincial distribution, since 98% of the losses occurred in the Northwestern Region.

Fire depletions occurred in a total of 13 forest management units (Table 3). Seven of those management units were in the Northwestern Region. Nineteen forest fires over 40 ha (gross total) in size occurred in these seven forest management units in the Northwestern Region.

The most significant depletions occurred in management units 320 and 731. Management unit 320 is the Packwash Management Unit in the Red Lake District, and makes up part of the Boise Cascade limit. Management unit 731 is the Minaki Crown Management Unit.

The depletion in management unit 320 was 5.27 million m^3 of wood on 32,379 ha of production forest. Depletions occurred primarily in the jack pine and spruce working groups. As Table 4 shows, depletion in these two working groups was 4.37 million m^3 or 83% of the total depletion within the management unit. The remaining 17% occurred in poplar and white birch working groups. The statistics for depletion by age class show that the single largest depletion occurred in the 101- to 120-year age class with 1.70 million m^3 or 34% of the total depletion within the unit. Approximately 48% of the losses in this management unit occurred between ages 61 and 100 years. Report 11 from the fire depletion system

Table 2. Provincial fire depletions summary for 1983 by region and working group.

Region		White pine (*Pinus strobus* L.)	Red pine (*P. resinosa* Ait.)	Jack pine	Spruce	Hardwood	Poplar	White birch (*Betula papyrifera* Marsh.)	Totals
Northwestern	Vol[a]	0.0	0.0	6,812,241.9	4,960,980.5	0.0	2,300,231.0	8,514.5	14,081,967.9
	Area[b]	0.0	0.0	70,377.3	36,193.5	0.0	12,315.0	114.9	119,000.7
North Central	Vol	0.0	0.0	0.0	193,009.2	0.0	48,310.0	8,352.6	249,672.8
	Area	0.0	0.0	0.0	1,475.5	0.0	305.1	83.0	1,863.6
Northern	Vol	0.0	0.0	5,553.7	23,024.3	0.0	0.0	15,942.9	44,520.8
	Area	0.0	0.0	33.2	214.9	0.0	0.0	127.9	376.0
Northeastern	Vol	66,810.3	0.0	0.0	4,639.5	0.0	0.0	0.0	71,449.8
	Area	33.2	0.0	0.0	21.9	0.0	0.0	0.0	55.0
Algonquin	Vol	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals	Vol	66,810.3	0.0	6,817,795.6	5,181,653.4	0.0	2,348,542.0	32,810.0	14,447,611.2
	Area	33.2	0.0	70,410.5	37,905.7	0.0	12,620.1	325.8	121,295.3

[a] Gross total volume expressed in m^3
[b] Area expressed in ha

Table 3. 1983 fire impact inventory: forest fire depletions by forest management unit.

Management unit	Number of fires	Area affected (ha)	Volume depleted (m^3)
310	1	97.5	9,559.9
320	4	32,379.3	5,266,159.2
330	1	45.7	2,902.2
432	2	303.5	30,480.4
470	5	1,772.1	241,576.4
471	1	195.1	17,721.4
472	2	28,070.9	3,357,668.3
731	1	54,571.9	4,932,690.8
840	1	695.7	88,442.8
874	1	869.3	134,766.5
Northwestern Region	19	119,000.7	14,081,967.9
069	1	376.4	47,239.9
173	1	516.8	69,670.2
178	1	52.6	6,966.9
244	1	84.2	8,493.5
245	1	833.7	117,302.2
Northern Region	4	1,863.6	249,672.8
011	1	85.8	8,284.1
868	1	290.2	36,236.6
North Central Region	2	376.0	44,520.7
801	1	55.0	71,449.8
Northeastern Region	1	55.0	71,449.8
Provincial Totals	26	121,295.3	14,447,611.2

(Table 5) also shows that the majority of the depletions in management unit 320 occurred in site class 2 forest; approximately 70% or 3.67 million m^3 were depleted from 21,139 ha of site class 2 forest and accounted for 65% of total area depleted in the management unit.

Limitations of the Current Depletion System

The fire depletion system is a provincial system capable of producing statistics on wood fiber depletion unlike any previous province-wide system; however, there are some limitations of which users should be aware. One of the most significant factors affecting the accuracy of the statistics of the fire depletion system is the degree of accuracy of the FRI system in utilizing normal yield volume equations to calculate volume losses. Volume calculations from FRI data have been criticized for overestimating volumes on production areas[3]. Raymond noted in a preliminary report on the comparison of FRI and operational-cruise volumes that FRI calculated volumes may be overestimating actual volumes by as much as 25%. If this is indeed true then the fire depletion system is also overestimating volume losses.

This fire depletion system simply produces statistics on volume and area of production forest losses. Actual impact of these losses is not addressed in the system. The impact in some cases is implied by the magnitude of the figures; however, accurate impact

[3] Raymond, P. 1974. Inventory-based forest management--a preliminary comparison and FRI and operational cruise volumes. Ont. Min. Nat. Resour., Toronto, Ont. Intern. Rep. 57 p.

Table 4. Fire depletion for management unit 320, 1983 by working group and age class.

District(s): 15 0 0 0 0 Twp/BSMP(S): 504,942 505,934 505,942 506,934 506,942 507,934 507,941 507,942 508,941 505,941
Fire number(s): KEN.73 RED.162 RED.149 RED.157

Working group		Age class								
		B&S	0-20	21-40	41-60	61-80	81-100	101-120	121+	Totals
White pine	Vol[a]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Area[b]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Stands	0	0	0	0	0	0	0	0	0
Red pine	Vol	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Stands	0	0	0	0	0	0	0	0	0
Jack pine	Vol	0.0	0.0	3,042.2	33,455.9	543,068.2	694,601.3	263,700.7	2,646.1	1,540,514.4
	Area	10.5	0.0	43.7	212.1	4,031.9	4,889.0	1,633.3	14.6	10,835.1
	Stands	1	0	2	9	119	106	44	1	282
Spruce	Vol	0.0	0.0	12,657.4	157,347.0	198,337.1	326,191.4	1,329,562.0	806,781.7	2,830,876.6
	Area	314.0	0.0	212.1	1,634.1	1,597.7	1,984.2	7,799.9	4360.9	17,902.9
	Stands	23	0	8	46	64	92	243	99	575
Hard-wood	Vol	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Stands	0	0	0	0	0	0	0	0	0
Poplar	Vol	0.0	0.0	0.0	0.0	265,905.7	522,844.7	104,174.1	0.0	892,924.5
	Area	35.2	0.0	0.0	0.0	1,007.3	2,168.3	393.0	0.0	3,603.7
	Stands	2	0	0	0	33	60	3	0	98
White birch	Vol	0.0	0.0	1,843.8	0.0	0.0	0.0	0.0	0.0	1,843.8
	Area	0.0	0.0	37.6	0.0	0.0	0.0	0.0	0.0	37.6
	Stands	0	0	1	0	0	0	0	0	1
Totals	Vol	0.0	0.0	17,543.4	190,802.9	1,007,311.0	1,543,637.3	1,697,436.8	809,427.7	5,266,159.2
	Area	359.8	0.0	293.4	1,846.2	6,636.8	9,041.5	9,826.2	4,375.5	32,379.3
	Stands	26	0	11	55	216	258	290	100	956

[a] Gross total volume expressed in m^3
[b] Area expressed in ha

must be determined by additional analysis. The analysis must be performed at various levels so that a true reflection of fire impact can be obtained. The degree of impact on wood supply on a provincial scale may differ from the local impact of fire depletion in a particular management unit, region, or wood supply zone around a forest products mill. It is not the intent of the fire depletion system to describe fire impact but it will provide the right data in sufficient detail so that improved fire impact analysis can be performed by both fire and forest management staff.

The current fire depletion system provides summaries of losses by management area but makes no reference to ownership. For example, there are no comparisons of losses on crown and private land as have been recorded historically in the fire records system. Losses in provincial parks or reserves where production forest may be inventoried on the FRI system are not identified. Depletions in these and other categories are under consideration for eventual inclusion in the system. Users are encouraged to provide feedback on data outputs and potential improvements.

Applications in Fire Management

The fire manager has several uses for these fire depletion statistics. First, he can increase his awareness of losses caused by fire so that he is able to communicate more effectively with forest managers. This is be-

Table 5. Fire depletion for management unit 320, 1983 by working group and site class.

District(s): 15 0 0 0 0 Twp/BSMP(S): 504,942 505,934 505,942 506,934 506,942 507,934 507,941 507,942 508,941 505,941
Fire number(s): KEN.73 RED.162 RED.149 RED.157

Working group		Site class 1	Site class 2	Site class 3	Site class 4	Totals
White pine	Vol (m^3)	0.0	0.0	0.0	0.0	0.0
	Area (ha)	0.0	0.0	0.0	0.0	0.0
	Stands	0	0	0	0	0
Red pine	Vol (m^3)	0.0	0.0	0.0	0.0	0.0
	Area (ha)	0.0	0.0	0.0	0.0	0.0
	Stands	0	0	0	0	0
Jack pine	Vol (m^3)	54,469.2	1,021,087.0	464,958.1	0.0	1,540,514.4
	Area (ha)	261.4	6,028.2	4,036.7	508.7	10,835.1
	Stands	9	156	104	13	282
Spruce	Vol (m^3)	792,690.4	1,977,906.9	60,279.3	0.0	2,830,876.6
	Area (ha)	4,404.6	12,639.6	700.9	157.8	17,902.9
	Stands	132	382	44	17	575
Hardwood	Vol (m^3)	0.0	0.0	0.0	0.0	0.0
	Area (ha)	0.0	0.0	0.0	0.0	0.0
	Stands	0	0	0	0	0
Poplar	Vol (m^3)	13,231.7	670,166.1	209,526.6	0.0	892,924.5
	Area (ha)	29.5	2,433.8	1,140.4	0.0	3,603.7
	Stands	3	60	35	0	98
White birch	Vol (m^3)	0.0	1,843.8	0.0	0.0	1,843.8
	Area (ha)	0.0	37.6	0.0	0.0	37.6
	Stands	0	1	0	0	1
Totals	Vol (m^3)	860,391.4	3,671,003.7	734,764.0	0.0	5,266,159.2
	Area (ha)	4,695.6	21,139.2	5,878.1	666.5	32,379.3
	Stands	144	599	183	30	956

coming increasingly important since fire managers, in conjunction with resource managers, are developing management systems whereby specific fire management objectives with respect to protection levels are identified. Forest management protection needs are among the most significant elements in the set of fire management objectives in areas of the province that are being and will be harvested. This fire depletion system allows for the measurement of fire losses and therefore permits fire managers to evaluate protection level objectives and to determine fire impact on forest management.

Forest Resource Inventory [4]

The FRI is conducted on a 20-year cycle (see Fig. 4). Inventory data collection, compilation and distribution are done from head office. At present the data sets in head office are not usually updated following their distribution to the field. Even though field

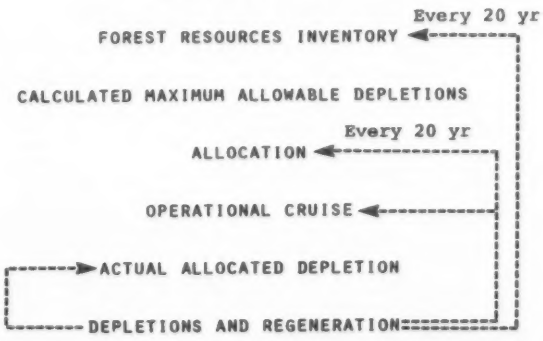

Figure 4. Cycles for data update and control.

[4] A complete description of the FRI for Ontario is given in Anon. (1978).

offices may update the forest stand map, the FRI ledger information is generally not changed. Hence, the FRI data in head office may very well be out of date.

A stand is the ultimate basic recording unit in the FRI. Stands are uniquely identified in Ontario by their map sheet number and stand number. Several important forest management criteria are associated with every stand. These include ownership, working group, age class, site class, species composition, stocking, area, volume and increment (see Fig. 5).

A. CURRENT	EXAMPLE
1. MANAGEMENT UNIT/WORKING CIRCLE	17401
*2. UNIQUE NUMBER	149
*3. WORKING GROUP	Sb
*4. SPECIES COMPOSITION	$Sb_5Pj_2Po_2B_1$
*5. AGE/HEIGHT/STOCKING	90-17-0.8
*6. SITE CLASS	1
*7. AREA	48
*8. OWNERSHIP/LAND US.	1
9. REGION/DISTRICT	32
10. GROSS TOTAL VOLUME/UNIT AREA	175
11. CURRENT ANNUAL INCREMENT/UNIT AREA	2.0

B. PROPOSED ADDITIONS

12. POLYGON TYPE
13. OPERABILITY
14. LICENCE NO.
15. BASAL AREA
16. NET MERCHANITABLE VOLUME
17. PLANNING (ALLOCATION)
18. DEPLETION RECORDS
19. GEOCODE
20. ACTIVITY CLASS
21. ACTIVITY DATE

*SHOWN ON FOREST STAND MAP

Figure 5. Forest resour.. inventory stand description (for a specified map sheet).

Previous fire reports did not describe the fire damage in FRI data terms. This made it exceptionally difficult to translate the impact of fire on forest management. The new recording system is therefore welcome, but how do forest managers use these data?

Long-term Information on the Forest Estate (LIFE)

Control is a vital forest management function. Control requires a feedback of data that describe what actually happened; then, by means of this feedback, the new actions are adjusted to fulfil management objectives.

Forest management action results in several events, of which the major ones are depletions of the productive forest base, accruals to the productive forest base, changes in access (roads), and changes in legal authorizations (timber licensing).

Depletions include cutting, natural catastrophes (e.g., fire), losses due to pests, land use changes (e.g., creation of a park), and ownership changes. The forest manager needs feedback on all these events. In certain regions of Ontario the magnitude and location of the fire loss are very important. The key to the utility of this feedback is the form and format of the data.

The LIFE project is a logical continuation of Dixon's (1983) report. The components of LIFE are shown in Figure 6. Two essential functions are the production of annual statistics--an annual statement of what happened, and an update of the basic FRI data sets. The basic data sets in LIFE are the data of the management units. However, through combination it will be possible to portray what is happening at a regional and provincial level. We will have a provincial forest inventory that is as up to date as data collection will allow. The success of LIFE, however, is predicated on the availability of depletion and accrual data as expressed in FRI components. It requires areas by ownership, management unit (or map sheet), working group, and age class. Notice that these are aggregate data and not stand data. LIFE is not organized or updated on a stand by stand basis, even though such data are necessary to produce aggregates.

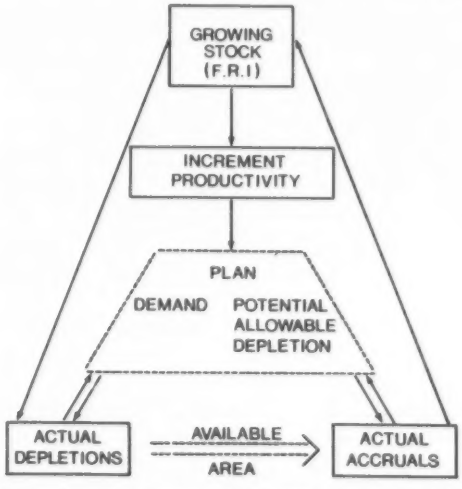

Figure 6. Long-term information of the forest estate.

Over time these annual statistics will result in trends. We will be able to analyze these past trends and proceed to the second use of fire depletion data in FRI format for forest management. This use is in prediction (or planning).

Production Policy

In 1972 crown foresters in Ontario received formal provincial Cabinet approval of the Ontario Forest Production Policy. In essence we were to have an annual supply of 9.1 million cunits of wood by the year 2020. Internally this policy was reviewed in 1977 and 1982 and changes were made in the method of delivering this target. In the 1982 review a simplistic FRI-based model was used to show how we might take today's forest and manage it to produce the stipulated target by 2020.

A very simple picture of what will happen is given in Figure 7. Here the changes to the growing stock (tree volumes) over time are shown. The old forest (the existing forest) is gradually but completely depleted and is replaced by the new forest. In the production policy analyses and simulations the components are the same as in LIFE. There is the existing FRI, there are depletions including fire, and there is accrual in the regeneration and growth of the forest. The trend analyses of LIFE will help us to calibrate the prediction model better.

Figure 8 illustrates another way of portraying the production policy simulation. Again, over time, certain volumes will become

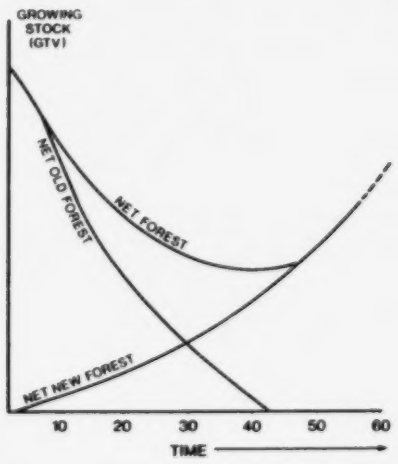

Figure 7. Changes to the present growing stock of a hypothetical forest over time.

available and certain volumes will be lost. In terms of efficiency the forest manager would like to manipulate the forest to achieve the maximum benefit in terms of wood, profit and jobs and minimize the losses to fire, pests, natural mortality and zone outs[5]. Simulation lets the forest manager evaluate the actions that can best manipulate the forest for specific levels of dollars, manpower and available expertise.

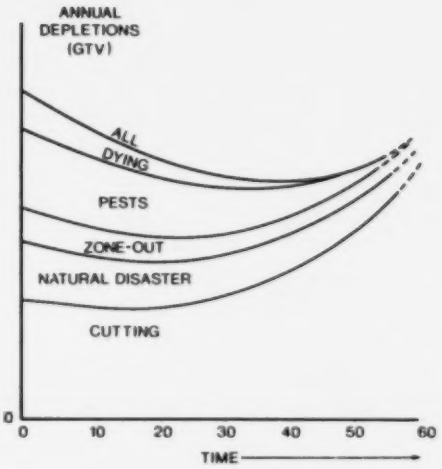

Figure 8. Changes to annual depletion of a hypothetical forest over time.

Forest managers have made several simulations with this simple model. It is interactive and forces the user to answer certain questions (see Fig. 9), among them: "How much forest will go up in smoke in the next five years?" When we first ran this in 1982 we had 10 years of history in the existing fire reports. We had to guess whether the data covered all land or all productive land, had to guess which burns were on unencumbered crown land and which in parks, and had to assume that all age classes had an equal probability of being burnt. We had no idea about which working groups were burnt. A comparison of what we used and what took place in 1983 is given in Table 6.

Coupled with all these assumptions was the even bigger one about future losses due to fire. Even though past data were labelled in an FRI format the future estimates are even

5 "Zone out" covers actions whereby land is taken out of the unencumbered productive forest land base and its use is changed, e.g., to zones that are not cut.

Table 6. Fire depletions (1983) compared with annual estimates used in production policy (crown land and patent land combined).

Data	Region	Barren and scattered	1-20	21-40	41-60	61-80	81-100	101-120	121+	Total	Merchantable volume (m^3)
		(ha)									
Actual	Northwestern	922	-	713	21,153	27,488	26,653	23,041	8,076	108,046	11,966
Prod. policy	North Central	26,154	8,718	7,442	15,064	18,814	18,192	16,285	11,980	122,649	12,074
Actual	Northern	-	-	6	107	-	-	22	168	303	100
Prod. policy	Northeastern	762	254	141	315	454	430	396	396	3,148	313

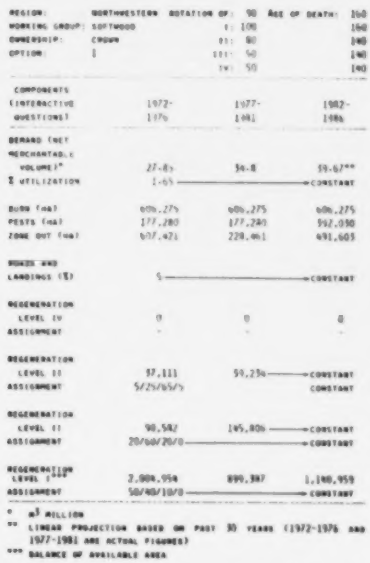

Figure 9. Questions in production policy simulation.

more speculative. Until we have a better calibration of past trends and an indication of which species, age classes, or sets of conditions are more susceptible to damage, predictions are imperfect. Nevertheless, the forest manager will continue to use this tool. Sensitivity analysis lets the manager ascertain which, if any, of the "controllable" events have the greatest impact on the future forest. These key factors are the ones upon which we will concentrate. We refine their measurement and calibration and, more importantly, we concentrate on controlling them in real life.

Priority Setting for Protection

The local forest manager has areas of different value. The areas vary in site productivity, in maturity, in accessibility and in investment costs to date. It is important for the manager to evaluate and rank the relative importance of these areas.

This ranking can be for several purposes, one of which is to rate the importance of protection. If we vary the intensity of fire prevention and/or suppression, the forest manager should then indicate which areas are of key importance. This sort of forest management is taking place in Red Lake District. It requires the same sort of historical trend data cited for LIFE above. It also requires the impact analysis methodology described for the production policy. Finally it needs economic analysis to compare the dollar values and their relative worth in the local economy. This particular function also utilizes the FRI attribute data, the stand descriptions, and the forest stand map. In this priority ranking, the determination and illustration of where these areas are is of great significance. Again, the mapping of fire damage in an FRI format has greatly helped forest management.

Literature Cited

Anon. 1978. Forest inventory procedure for Ontario. 3rd. ed. Ont. Min. Nat. Resour., Toronto, Ont. 30 p.

Dixon, R.M. 1963. The forest resources of Ontario. Ont. Dep. Lands For., Toronto, Ont. 108 p.

DECISION ANALYSIS FOR PRESCRIBED BURN PLANNING

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Abstract.--Decision analysis techniques were used to develop a planning methodology for evaluating forest site preparation (prescribed fire and mechanical scarification), regeneration (seed, bare-root planting stock, and container planting stock), and tending (precommercial thinning and fertilizing) strategies. Although our computer-based mathematical model is designed to evaluate management strategies for jack pine sand flat cutovers in northern Ontario, the methodology can readily be adapted to other sites and species.

Résumé.--Les techniques d'analyse de décision ont servi à élaborer une méthode de planification pour évaluer les stratégies de préparation du sol forestier (brûlage dirigé et scarification mécanique), de régénération (par ensemencement ou par plantation de matériel à racines nues ou en récipients) et de soins culturaux (éclaircies avant le stade commercialisable et amendements). Même si notre modèle informatique est conçu pour évaluer les stratégies d'aménagement des peuplements de pin gris, sur terrains plats sablonneux, après la coupe, dans le nord de l'Ontario, il peut facilement s'adapter à d'autres stations et essences.

Introduction

As far back as 1976, at an Ontario Ministry of Natural Resources (OMNR) prescribed burn seminar at Dorset, Ontario, it was evident that prescribed burn planners found it difficult to develop prescriptions that would satisfy both fire control and land management objectives. They and their clients were particularly troubled by the fact that many of the fire weather prescriptions they specified did not occur frequently enough for them to conduct many of the burns they planned.

In response to that planning problem, Martell (1978) developed PBWX, an interactive computer program that uses historical fire weather data to determine how frequently a specified fire weather prescription occurred in the past, on the assumption that such information is a good measure of the likelihood that the prescription will occur in the future. Prescribed burn planners who used the system then began to ask, "How many days are enough?" We decided to investigate the problem and developed a planning methodology that answers that question and can be used to help resolve many of the problems that complicate silvicultural planning. For the benefit of those who asked how many days are enough, the answer is, it depends on very many factors that together determine the cost effectiveness of a forest management program.

Our research objective was to develop a comprehensive planning procedure that explicitly addresses the many important biological, economic, and technological factors that influence silvicultural planning decisions. We began work with jack pine (*Pinus banksiana* Lamb.) sand flat cutovers because of their economic importance, their relative simplic-

ity, and the fact that prescribed fire is often used to help regenerate such sites in Ontario. We soon realized that it was necessary to deal with more than just prescribed fire. We eventually developed a planning procedure that can be used to evaluate site preparation, regeneration, and tending strategies on the basis of expected net present worth, by taking into account all the significant costs and revenues that might be incurred from the time site preparation planning begins until the next stand is harvested.

Decision Analysis Approach

We used the decision analysis approach developed by Howard (1966) and his associates at Stanford Research Institute in California. Decision analysis is a powerful operational research technique that can be used to help resolve complex decision-making problems that involve uncertainty. Decision analysis techniques have been applied to a number of forest fire management problems including the analysis of fuel management alternatives, many aspects of which are somewhat similar to prescribed burn planning (see, for example, Hirsch et al. 1981). Since a detailed discussion of our analysis is beyond the scope of this paper, we refer those of you who are interested to Fullerton (1983) for such details.

Decision Analysis of Silvicultural Treatments

Very briefly, we conducted our prescribed burn planning decision analysis as follows. Our first task was to identify the decision maker, his objectives, and the alternatives available to him. For the purpose of our research project, we assumed that our decision maker is the land manager responsible for the site, and his objective is to maximize the net monetary return from the land. We initially limited ourselves to two site treatment alternatives, namely, prescribed fire and mechanical scarification. However, it soon became clear that site preparation decisions cannot be isolated from other forest management decisions, and we subsequently expanded the scope of our analysis to include regeneration and tending activities. Our next task was to identify the important variables that influence the decision. Each variable was classified as either a decision variable or a state variable. Decision variables are those that are controlled by the decision maker and thus define the management strategies or alternatives to be evaluated (e.g., the site treatment: burn or scarify). State variables are those that are not controlled by the decision maker and thus define the environment to which the management strategies are applied (e.g., stumpage rates).

Our decision variables are listed below. They define a total of 24 alternatives or management strategies that can be applied to a jack pine sand flat cutover.

- Site preparation method
- Regeneration stock type
- Maximum regeneration time lag
- Thinning policy
- Thinning year
- Fertilization year
- BUI for prescribed burn
- Seeding intensity

Our state variables, which define the environments to which the management strategies might be applied, are as follows:

- Year that preparation occurs
- Site class of site being prepared
- Area of site being prepared
- Site class of surrounding forest
- Age of surrounding forest
- Product class of surrounding forest
- Stocking level of surrounding forest
- Real interest rate
- Pulpwood value per m^3
- Sawlog value per m^3
- Probability of a prescribed burn wildfire
- Area of prescribed burn wildfire
- Probability of a mechanical scarification wildfire
- Area of a mechanical scarification wildfire
- Suppression cost of a prescribed burn wildfire
- Suppression cost of a mechanical scarification wildfire
- Expected mechanical scarification gross mineral soil exposure
- Mean duff depth
- Duff depth standard deviation
- Preburn slash loading
- Prescribed burn operating cost
- Mechanical scarification operating cost
- Prescribed burn cancellation cost
- Mechanical scarification cancellation cost
- Probability of seed germination on receptive areas
- Probability of seed germination on unreceptive areas
- Bare root planting cost
- Container planting cost
- Seeding cost
- Bare root stock cost
- Container stock cost
- Planting intensity
- Seed cost per kg
- Number of seeds per kg
- Portion of seed stock cost charged to site per preparation cancellation

Portion of bare root stock cost charged to site per preparation cancellation
Portion of container stock cost charged to site per preparation cancellation
Fertilization factor - site class I
Fertilization factor - site class II
Fertilization factor - site class III
Seeding factor
Cost of fertilization
Cost of thinning
Cost of planning a mechanical scarification
Cost per fuel loading triangle
Cost of writing a prescribed burn plan
Cost of approving a prescribed burn plan
Cost of approving a mechanical scarification plan

We then developed a mathematical model that predicts the extent to which each alternative will achieve the decision maker's objective. It is a large FORTRAN computer program that computes the net present worth that will result if a specified alternative is applied to a particular environment.

Sensitivity Analysis

Having developed a mathematical model of the system, we then conducted what decision analysts refer to as a sensitivity analysis. A sensitivity analysis is essentially a formal procedure for investigating the extent to which modelling assumptions and estimates of model parameters influence conclusions based on predictions produced by a mathematical model.

We focussed our attention on the state variables for which we felt fire or forest managers would have difficulty providing estimates. The state variables we selected for sensitivity analysis are shown below.

Real interest rate
Year the site was prepared
Thinning cost
Probability of a prescribed burn wildfire
Prescribed burn wildfire size
Prescribed burn wildfire suppression cost
Probability of a mechanical scarification wildfire
Mechanical scarification wildfire size
Mechanical scarification wildfire suppression cost

We began by setting all the decision and state variables equal to nominal or representative values, and specifying a range of conceivable values for each of the state variables slated for sensitivity analysis. Each of the variables slated for sensitivity analysis was taken, one at a time, and allowed to vary throughout its range of conceivable values. The net present worth of each of the 24 management strategies was computed and plotted as a function of the variable under consideration. In order to accomplish this we had to run the model 1,608 times and use a color graphics display system to produce the graphs. These graphs enabled us to identify dominated strategies (i.e., strategies that are not cost effective anywhere within the range of conceivable values under consideration), and the extent to which variation in the state variables influences the choice of an optimal strategy. State variables that significantly influence the choice of optimal strategies were designated crucial variables, and subjected to a probabilistic analysis which is described in Fullerton (1983).

Results

The most important finding that resulted from our sensitivity analysis was that aerial seeding strategies clearly dominate (i.e., are much more economical than) planting strategies. We also found that choices concerning the use of prescribed fire and mechanical scarification and the application of thinning and fertilization treatments are sensitive to the following variables:

the year the site is prepared
prescribed burn wildfire size
mechanical scarification wildfire size
real interest rate
thinning cost.

Discussion

Space limitations preclude a detailed discussion of many aspects of our decision analysis of jack pine silvicultural planning. We used decision trees to model uncertainty and its effect upon the choice of action. We also conducted an evaluation of perfect information, a powerful decision analysis procedure that can be used to evaluate research programs and information systems that might reduce some of the uncertainty that complicates silvicultural decision making. Interested readers are referred to Fullerton (1983) for details.

Although we did not develop an operational decision support system we feel that with some additional effort, such a system could be developed, and would be of considerable benefit to fire and forest managers engaged in silvicultural operations in Ontario.

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Literature Cited

Fullerton, J.M. 1983. A planning methodology for evaluating site preparation, regeneration and tending strategies for jack pine sand flat cutovers. M.Sc.F. Thesis. Fac. For., Univ. Toronto, Toronto, Ont. 208 p.

Hirsch, S.N., Radloff, D.L., Schopfer, W.C., Wolfe, M.L., and Yancik, R.F. 1981. The activity fuel appraisal process: instructions and examples. USDA For. Serv., Rocky Mt. For. and Range Exp. Stn., Gen. Tech. Rep. RM-83. 46 p.

Howard, R.A. 1966. Decision analysis: applied decision theory. p. 55-71 *in* D.B. Hertz and J. Melese, *Ed.* Proceedings of the fourth international conference on operational research. Wiley Interscience, New York.

Martell, D.L. 1978. The use of historical fire weather data for prescribed burn planning. For. Chron. 54(2):96-98.

REGENERATION SUCCESS AS A MEASURE OF SITE PREPARATION EFFECTIVENESS: PRESCRIBED FIRE VERSUS SCARIFICATION

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Abstract.--On the basis of growth attributes, prescribed fire is to be preferred to no site preparation treatment at all in plantation establishments in the Northern Clay Belt Region of Ontario. Comparisons between prescribed fire and mechanical scarification (barrels and chains/Young's teeth) as site preparation methods showed no differences in plantation growth. Results indicate that the most cost-effective site preparation method should be chosen.

Résumé.--En se fondant sur les attributs de la croissance, il faut préférer le brûlage dirigé à l'absence de préparation du sol, dans les plantations de la région argileuse du Nord de l'Ontario. La croissance des plants ne diffère pas selon qu'on a préparé le sol par brûlage dirigé ou par scarification mécanique (cylindres dentés et chaînes/dents d'Young). Les résultats montrent que c'est la méthode de préparation du sol la plus économique qui devrait être retenue.

Introduction

A resource manager must make rational decisions on the use of prescribed fire as a management tool on the basis of existing land use objectives, characterization of fires as to their expected behavior, and the prediction of biological effects according to the expected fire behavior (Methven 1978). The art of predicting expected fire behavior in Ontario has received much attention in recent years (Chrosciewicz 1959, 1967, Stocks and Walker 1972, McRae 1980). Fire managers feel confident in using these fire behavior guidelines to develop prescribed burning prescriptions. Fire is a highly variable phenomenon causing various biological reponses commonly referred to as fire effects[1]. The effects of fire are not well understood, especially in reference to the nature of the fire, since traditionally fire researchers have been concerned with fire behavior, and ecologists have been concerned with fire effects only. Certainly, the economic impact of fire warrants an integration of these two fields (fire and ecology) to provide forest managers with adequate information for resource management decision-making.

Forest managers require large amounts of data to make effective decisions on the proper site preparation method to use for a particular forest site (Fullerton 1984). Many of these data still need to be quantified. One variable that requires research is the beneficial response of a particular site preparation method to the survival and growth of seedling stock. Funding during 1981 through the Department of Regional Economic Expansion (DREE), and later the Canada-Ontario Forest Management Subsidiary Agreement (FMSA), permitted the Ontario Ministry of Natural Resources (OMNR) to proceed to answer this question. Staff of the prescribed fire research study at the Great Lakes Forest Research Centre served as scientific authority for the study. It is the purpose of this paper to explain the results of this study.

[1] Alexander, M.E. 1979. Forest fire description and biological effects. Paper presented at Vegetation and Wildlife Interrelations Course, University of Guelph, 21 November 1979. 12 p.

Objective

The objective of the study was to investigate the effectiveness of prescribed burning as a site preparation method in comparison with other site treatment methods, either mechanical scarification or no treatment at all, in the Clay Belt Region of northern Ontario.

Study Areas

To provide a quick answer to the problem, three plantations were identified as suitable for the study. The main criteria for this selection were that the plantations be located in the Clay Belt Region, that the history of the plantations be known, and that they be of an age to indicate possible effects of site treatment (more than 5 years old). This route was taken to reduce the time needed to answer the problem since a formal research study would have taken many years to complete. The results are interim answers that will permit forest managers to make more rational decisions about site preparation methods for this region.

The three plantations are located in the OMNR District of Kapuskasing (Fig. 1). This district has had a long history of prescribed burning for site preparation and contains some older plantations on sites prepared by this method. The plantstions are ideally located since adjacent to each is some other form of site preparation on the same cutover. Treatments were with barrels and chains or Young's teeth, or else there was no treatment at all (Table 1). It was hoped that, by having the comparison sites together, variability of planting stock, site types, and weather could be reduced.

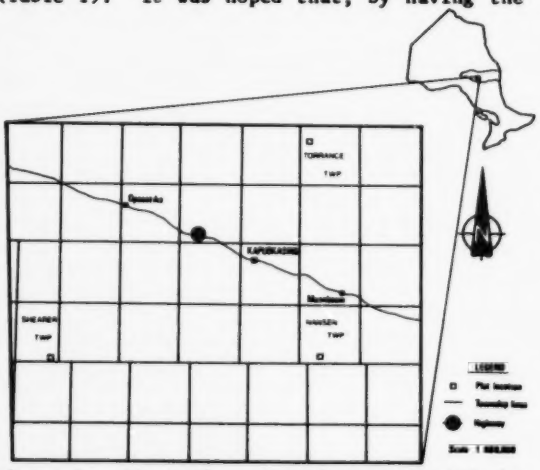

Figure 1. Plantation locations assessed by this project in the Clay Belt Region of Ontario.

Table 1. Treatment summary by township.

Treatment	Year of treatment		
	Hansen	Torrance	Shearer
Prescribed burn	1973	1975	1974
Scarification	1973 (barrels and chains)	1975 (Young's teeth)	--
Planting	1974	1976	1975
Aerial herbicide spraying	1979	1977, 1978	1977, 1980

Prior to harvesting, the areas selected supported a boreal mixedwood forest type[2] that included balsam fir (*Abies balsamea* [L.] Mill.), black spruce (*Picea mariana* [Mill.] B.S.P.), white spruce (*P. glauca* [Moench] Voss), trembling aspen (*Populus tremuloides* Michx.) and white birch (*Betula papyrifera* Marsh.). The areas are classified as mixedwood-herb rich (OG 7) and hardwood-alder (OG 10) operational group by a forest ecosystem classification system (Jones et al. 1983) designed for the Clay Belt Region of site region 3E (Hills 1961). Soils are calcareous, fine, loamy clay and are classified as rapidly drained to moderately well drained.

Method

A detailed summary of silvicultural treatment was initiated after the three plantation areas were identified (Table 1). The fuel codes and fire behavior indices of the Canadian Forest Fire Weather Index (CFFWI) system (Anon. 1984) that prevailed during the three prescribed burns were noted (Table 2) since these would give an indication of fire behavior on these burns. Unfortunately, the base weather station was located in Kapuskasing, some distance from all three prescribed burn sites.

[2] Weingartner, D.H. and Basham, J.T., *Ed.* 1979. Forest management and research needs in the boreal mixedwood forest of Ontario. Unpublished file report prepared by the Spruce-Fir-Aspen Forest Research Committee, Canada-Ontario Joint Forestry Research Committee. 90 p.

Table 2. Fire weather data for prescribed burns by township.

Township	Date	Temp. (°C)	R.H. (%)	Wind speed (km/hr)	Canadian Forest Fire Weather Index System					
					FFMC[a]	DMC[b]	DC[c]	ISI[d]	BUI[e]	FWI[f]
Nansen	26.7.1973	26.7	61	19	90	29	150	10	39	20
Shearer	26.6.1974	26.7	54	21	88	26	231	9	44	20
	10.9.1974	15.6	51	15	88	32	308	11	51	24
Torrance	26.6.1975	27.0	54	21	88	26	223	9	44	20

[a] Fine fuel moisture code
[b] Duff moisture code
[c] Drought code
[d] Initial spread index
[e] Buildup index
[f] Fire weather index

An intensive assessment (1981-1982) was conducted for the first two years on the basis of milacre plots placed around a 10 m x 10 m square. A number of tree parameters were measured during this assessment. This procedure was time consuming and progress was slow. The small number of trees assessed in this way meant that results would be inconclusive because there was no adequate control and no record of the original stock or planting quality. For the 1983 season, a less detailed assessment was conducted to increase production so that in light of the poor stock and planting quality records, trends might be seen because of sheer number (Table 3).

Three major tree growth parameters were measured during the 1983 assessment year: stump diameter taken 5 cm above the duff layer in lieu of diameter at breast height (DBH), total tree height, and average crown width (an average of two values taken at 90° to each other at the widest portion of the tree crown). Trees that had naturally seeded in were not assessed so that values calculated were for planted trees only. It is these measurements that will be discussed and interpreted.

Results and Discussion

The Nansen Township plantation was divided into three distinct areas on the basis of planting stock type. The results of the assessment done on this area are shown in Table 3. Area 1 showed no significant differences between treatments (prescribed burning vs barrels and chains), while area 2 had significantly larger stump diameters and total height for the scarified sites and area 3 had a significantly larger total height for the prescribed burn site. Certainly no trends were seen in this portion of the assessment.

Five different areas were identified in Torrance Township by planting stock type. The comparison between treatments (prescribed burning vs Young's teeth) showed no differences in growth patterns. Table 3 shows that, for areas 5 and 8, prescribed burning was more beneficial, while in areas 4 and 6, scarification was more beneficial. In area 7 there were no significant growth differences attributable to site treatment method.

Difficulties in making field comparisons became apparent in Torrance Township because of the lack of control in compatible tending treatments for both site preparation areas. For example, in 1977 and 1978, herbicide spraying to control vegetative competition around tree seedlings was undertaken only in small areas of the plantation. It is believed that there is a difference for area 4 where spraying was conducted in 1978 on the scarified area only. Figure 2 supports this hypothesis by showing mean annual height increments for each year of the trees' growth. This information was produced from a sample taken during the 1981-1982 field season in which the information on annual growth was more detailed than that from the 1983 sample.

Prior to 1976, while still in the nursery, the seedlings that were later planted on the scarified area showed a substantial growth difference: they were significantly larger in 1974, 1975, and 1976 than the seedlings planted later on the burn site (Fig. 2). The seedlings were planted in 1976 and showed no appreciable differences in annual height increments between 1977 and 1979. In 1978, a herbicide spraying is believed to have taken

Table 3. Growth response on the assessment areas.

Area	Stock type	Stump diameter (cm)	Height (cm)	Crown width (cm)	Sample size (number of trees)
		Nansen Township			
1B	Spruce Falls	2.4	103.1	45.9	93
1S	2-2 Sb	2.5	109.9	41.2	81
2B	Midhurst	2.4	105.1	41.9	48
2S	3-0 Sb	2.8*	119.0*	41.6	30
3B	Swastika	2.7	107.6*	40.3	39
3S	1½-1½ Sb	2.2	95.7	36.1	56
		Torrance Township			
4B	Midhurst	2.4	117.8	38.9	305
4S	1½-1½ Sb	3.3*	136.1*	45.7*	42
5B	Swastika	3.4*	133.8	49.4*	20
5S	1½-1½ Sb	2.8	128.9	43.8	36
6B	Swastika	2.2	86.1	33.8	24
6S	3-0 Sw	2.3	100.6*	36.5*	56
7B	Spruce Falls	3.1	134.4	48.7	225
7S	2-2 Sb	2.9	129.5	47.9	105
8B	Swastika	1.4	58.3	23.1*	116
8S	1-0 Sw	1.5	47.1	21.4	55
		Shearer Township			
9B	Swastika	3.0*	109.0*	41.1	36
9N	3-0 Sb	1.8	96.2	36.6	97
10B	Spruce Falls	2.6*	124.6*	46.3*	66
10N	2-2 Sb	2.1	97.0	37.6	97
11B	Swastika	2.0*	72.7	32.2	93
11N	1½-1½ Sw	1.7	78.9*	38.0*	170

* indicates significant difference at 95% level according to t-test.

place only on the scarified area. Time was needed for this spraying program to take effect, but results could be seen by the 1980 growing season. Significantly larger annual height increments were noted on the scarified site between 1980 and 1982. In the 1983 assessment this growth difference was noted (Table 3). The data indicate that growth figures for the three parameters were significantly higher for the trees planted on the scarified site, not because of differences in site preparation but because of different tending treatments.

The results from both Nansen and Torrance townships indicate no significant differences in the mechanical site preparation methods that were used in this comparison study with prescribed fire. Inasmuch as limited site preparation funds are available to local OMNR district offices, the results of this study would suggest that such funds should be used in the most cost effective site preparation program available. Of course, other variables not dealt with in this paper must be considered before a final decision is made with respect to a particular site preparation treatment.

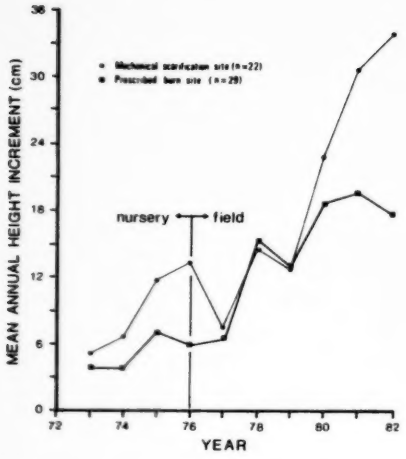

Figure 2. Mean annual height increments of trees measured on area 4 in Torrance Township.

A comparison of prescribed burning with no treatment at all was undertaken for the Shearer Township plantation. On areas 9 and 10 growth was significantly better on the prescribed burn site (Table 3). Area 11 was difficult to interpret since significantly larger stump diameters were measured on the burn sites while significantly larger heights and crown widths were measured on the untreated site. The data for Shearer Township suggest that prescribed burning is better than no site preparation treatment at all.

Percent stocking was calculated for the three study townships (Table 4). Although there was no obvious trend in favor of any one treatment, it was evident that stocking of natural regeneration on some of the burn sites could be higher than on adjacent untreated or scarified areas. Areas 1 and 4 had much higher stocking (both planted seedlings and total seedlings) on the burn areas than on the scarified areas.

Conclusion

The results of the study suggest that there are no major differences between prescribed burning and either barrels and chains or Young's teeth mechanical scarification as methods of site preparation. No major differences were observed in stump diameter, total height or crown width. The results indicate that the forest manager should choose the site preparation treatment that will be most cost effective since both types of treatment result in similar tree growth.

The use of prescribed fire as a site preparation treatment was seen to be more desirable than no treatment whatsoever. Better growth was recorded for plantations established on prescribed burn sites.

The interim results from the study can be used in a decision analysis designed for the selection of site preparation alternatives in areas of the Clay Belt Region of Ontario. Site treatment on a limited budget demands more information than is currently available to the forest manager. The consequences of

Table 4. Percent stocking.

Area	Stocking (%)[a]		
	Natural	Planted	Total
	Nansen Township		
1B	24	66	82
1S	10	49	55
2B	22	60	72
2S	20	68	76
3B	10	43	53
3S	17	49	59
	Torrance Township		
4B	1	86	86
4S	5	46	53
5B[b]	-	-	-
5S	-	-	-
6B[b]	-	-	-
6S	-	-	-
7B	3	61	64
7S	11	50	59
8B	6	59	63
8S	18	53	58
	Shearer Township		
9B	26	48	67
9S	48	42	73
10B	64	56	82
10S	32	34	62
11B	31	51	68
11S	30	36	56

[a] based on 2-m x 2-m (1 milacre) quadrats.
[b] Planting stock from areas 5 and 6 was intermixed on the same site, preventing an accurate stocking value for either area.

choosing a certain site preparation treatment need to be analyzed in more detail as part of a long-term research project. In the present study, because of its use of plantations established in the past, we were unable to control planting stock quality and tending operations to the degree desired.

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Literature Cited

Anon. 1984. Tables for the Canadian Forest Fire Weather Index System. Dep. Environ., Can. For. Serv., Ottawa, Ont. For. Tech. Rep. 25. 48 p.

Chrosciewicz, Z. 1959. Controlled burning experiments on jack pine sites. Can. Dep. North. Aff. Nat. Resour., For. Br., For. Res. Div., Ottawa, Ont. Tech. Note 72. 19 p.

Chrosciewicz, Z. 1967. Experimental burning for humus disposal on clear-cut jack pine sites in central Ontario. Can. Dep. For. Rur. Dev., For. Br., Ottawa, Ont. Publ. 1181. 23 p.

Fullerton, J.M. 1984. A planning methodology for evaluating site preparation, regeneration and tending strategies for jack pine sand flat cutovers. M.Sc. Thesis, Univ. Toronto. 207 p.

Hills, G.A. 1961. The ecological basis for land-use planning. Ont. Dep. Lands For., Toronto, Ont. Res. Rep. 46. 210 p. (Reprinted 1966).

Jones, R.K., Pierpoint, G., Wickware, G.M., Jeglum, J.K., Arnup, R.W., and Bowles, J.M. 1983. Field guide to forest ecosystem classification for the Clay Belt, site region 3e. Ont. Min. Nat. Resour., Toronto, Ont. 123 p.

M^{c}Rae, D.J. 1980. Preliminary fuel consumption guidelines for prescribed burning in Ontario slash fuel complexes. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-316. 25 p.

Methven, D.R. 1978. Fire research at the Petawawa Forest Experiment Station: the integration of fire behavior and forest ecology for management purposes. p. 23-27 *in* D.E. Dubé, *Comp.* Proc. Fire Ecology in Resource Management Workshop, Edmonton, Alta., 6-7 Dec. 1977. Dep. Environ., Can. For. Serv., Edmonton, Alta. Inf. Rep. NOR-X-210.

Stocks, B.J. and Walker, J.D. 1972. Fire behavior and fuel consumption in jack pine slash in Ontario. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-169. 19 p.

PRESCRIBED BURNING, NORTHERN REGION: TEAMWORK MAKES PRESCRIBED BURNING A SUCCESS

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Abstract.--This paper presents an overview of costs, benefits and results of past burning programs. Ways in which team work and site selection can increase the area burned and reduce unit costs are discussed. Burning budworm-killed balsam fir is seen as a new challenge for the forester and fire manager.

Résumé.--Les auteurs présentent les coûts, les avantages et les résultats des opérations antérieures de brûlage. Ils discutent des façons par lesquelles on peut augmenter la superficie traitée et réduire les coûts unitaires grâce au travail d'équipe et à la sélection des stations. Le brûlage des peuplements de sapin baumier tués par la tordeuse est perçu comme un nouveau défi pour le forestier et l'aménagiste.

Introduction

Prescribed burning is defined as the deliberate application of fire to land under certain conditions of weather, soil, moisture, time of day, fuel, etc., to achieve the necessary intensity of heat, fire, spread and consumption of organic matter for silviculture, wildlife, grazing, insect and disease control and fire hazard reduction.

After thinking about this definition, the forest manager must apply it to the management of a forest ecosystem, and decide if he can use prescribed burning as a management tool.

We believe that prescribed burning can and should be used in the management of most forest ecosystems. To date, however, prescribed burning has been used by managers in Ontario only as a minor tool in their day-to-day operational work. Therefore, if we as forest managers want to improve and expand the forest management program in Ontario, and work within the management constraints that are likely to be imposed on us over the next decade, we must use prescribed burning on a universal scale.

We have been told repeatedly that we must do more with less. Therefore, we must economize in our site preparation programs, and well planned prescribed burns will help us to do this.

Fire has been and always will be a natural force in the development of most forest ecosystems. There is probably scarcely a hectare of ground in northern Ontario that has not experienced the direct effects of fire. An age-class distribution map is nothing more than a mosaic showing us where and when fire has burned, and what it looked like. Therefore, this tool must be readily available to forest managers for their day to day silvicultural operations.

Prescribed burning is nothing new. In Ontario it has been available to the forest manager as an operational tool since 1965. That is not to say that it has been used effectively all that time. In most regions it has not been used at all, and in general the program has had its ups and downs. Although many excellent plantations have resulted from past burns, there have been numerous costly

wildfires as well as the Geraldton tragedy in our recent history. Throughout this entire period, senior management in the Ontario Ministry of Natural Resources (OMNR) has strongly supported staff and the prescribed burn program.

For the past three years, Ontario has carried out prescribed burns on an average of 4,000 ha per year, mostly in the Northern Region. By contrast, the province of British Columbia burned 86,710 ha in 1983 and averaged 71,332 ha per year for the past three years.

We believe that Ontario has the resources to carry out a much expanded prescribed burn program, and that such a program is essential to the long-term health of our forests. Long-range planning must become an integral part of our silvicultural programs.

Management objectives and the overall philosophy of the program must be spelled out in detail before any operational program is implemented. The forest manager must then consider all the silvicultural tools available to him (mechanical, manual, chemical, biological, fire, etc.) and determine which of these will help him achieve these objectives most effectively and economically. If he decides that prescribed burning is one tool he should use, then he must formulate detailed plans for doing so.

Planning for a prescribed burn involves considerably more than writing a burning plan. (This, in fact, is the final step in the planning process.) Prescribed burning must be planned on a 5-year basis and must form an integral part of management and operating plans for given areas in the province.

The major reasons for our failure to achieve as much as we should or could have achieved to date are our lack of long-term planning and our lack of a teamwork approach to the prescribed burn program.

A prescribed burn should be planned by a multi-discipline management team. The team must consider the following questions in its planning process:

1) Is prescribed burning the correct management practice for the particular forest site in question?

2) Is the cost:benefit ratio acceptable and is prescribed burning competitive with alternative treatment methods?

3) Have all the environmental and social impacts been considered?

4) Have all the risks, costs and other implications associated with escaped fire been considered?

We shall now attempt to describe for you a planning concept that should help the forest manager maximize his prescribed burn efforts, and shall propose solutions to some of the major problems that have caused our program to falter in the past.

Planning for a Prescribed Burn

Site Selection and Pre-cut Engineering

Site selection and pre-cut engineering are perhaps the most significant factors in reducing burning costs and increasing areas burned by prescription each year. Most forested townships in northern Ontario have numerous areas that could be burned easily by prescribed fire. Many of these areas are entirely surrounded by water, swamps or mature timber types that are virtually fireproof. If these areas were isolated for site treatment by prescribed fire, the cost per hectare would be extremely low. To reduce the high cost of site treatment, we must become more skilled at selecting these ideal burn areas. We can also design our cutting patterns so that burn sites are pre-engineered for prescribed fire application. The following seven site selection factors must be included in the selection of candidate burn areas:

1) Natural fire boundaries: swamps
creeks
lakes
standing timber
deciduous growth
roads

2) Shape of the burn: Round or square burn areas are easier to patrol and have a smaller perimeter than do rectangular or long, irregular burn areas.

3) Size of the burn: Candidate burn areas must be large enough that one can justify the high cost of aerial ignition and the expense of housing, feeding and paying the suppression crews. Areas between 100 and 1,000 ha are usually well within the size requirements for effective and economical prescribed burning.

4) Topography: Slope can play a significant role in controlling ignition on a prescribed burn. Hills sloping down to the outside boundaries of a prescribed fire are always an important factor in controlling those sections of fire edge.

5) Fuel types: Fuel within the prescribed burn area must have sufficient conifer content to carry and spread the fire. A rule of thumb is to look for 60-70% conifer slash content. Flammability of deciduous fuel types can be enhanced by the application of chemical leaf defoliant (2-4D). It is obviously better to have fire-resistant fuel types outside the prescribed burn boundaries to lessen the chance of fire escape.

6) Type of access: Limited access to a prescribed burn site will increase the cost per hectare considerably if extensive suppression effort is required to protect prescribed burn boundaries.

7) Adjacent values: "Adjacent values" can best be described as cut wood, plantations, cottage subdivisions, shoreline reservations and private property. Adjacent values will put pressure on a fire boss and will usually necessitate an additional suppression effort, with an attendant increase in suppression costs. Adjacent values, if extensive, could influence a manager's decision to conduct a prescribed burn.

Long-term Planning

The second major problem the burning program must address is long-term planning for prescribed fire.

To date, forest managers appear to have used prescribed fire with little preplanning, simply burning cutovers that could not be treated by other traditional methods. In some cases, they burned areas containing minimal conifer fuel types, with the result that burning was difficult and results were marginal. Very few of these sites were designated for prescribed fire treatment prior to cutting and most were cutovers proposed for burning and ignited the same year. Site selection to ensure that prescribed fire was a suitable site preparation tool and to reduce costs was only an afterthought. In many cases, natural fire boundaries were nonexistent while valuable cut timber was within or adjacent to the burn boundary, so that burning teams encountered problems. This short-term approach to prescribed fire planning must be discarded if we are to develop a major burn program in Ontario.

The key ingredient in long-term planning is the five-year operating plan. Such a plan will permit all candidate burn sites to be selected well in advance of cutting. Costs and expected results on each individual site should be the final criteria for selecting a method of site treatment. The analysis will give the unit forester a five-year prescribed burn forecast that can be used for budgeting and establishing yearly regeneration targets.

An Approach to Establishing a Five-year Prescribed Burn Forecast

1) The fire operations manager must analyze each township and each stand to be cut within the five-year operating area.

2) All natural boundaries within areas to be cut should be color-coded for easy identification.

3) Stands with sufficient conifer content to carry and spread fire should be highlighted.

4) Fixed values of importance should be identified.

5) At this point, a number of prime candidate burning chances should be evident throughout the five-year operating area.

6) Once individual burn sites have been identified, the cost per hectare should be estimated for each. This cost can be estimated fairly accurately on the basis of the seven site selection factors mentioned previously, combined with past burning experience (see Appendix). Although the estimate will be rough, it will become more accurate as fire managers gain burning experience.

7) The unit forester must make a judgment about whether the candidate burn sites should be treated by fire or by some other silvicultural method. This analysis can be based on an estimated cost and on expected results. By following a logical planning sequence he can get the most for his regeneration dollar.

8) Company foresters must also participate in the long-term planning process for prescribed burning. Interaction between OMNR and company foresters is essential to ensure that candidate areas are cut in one or two cutting seasons. Cut wood must be removed from burns and adjacent areas prior to ignition dates. Road and access patterns are important in the preliminary planning process as they influence both cost and the manner in which a burn team conducts burn projects.

An example of the process: As an example of how the process works, let us suppose that the

operations manager originally selected 50 candidate burn sites from the five-year operating plan. Using sound forestry, cost estimates and expected regeneration results, the unit forester reduced the original proposal to 30 burns.

The company forester with his knowledge of road building, logging practices and the wood supply needed for the mill further reduced the proposed burns to 20 in the five-year period. Thus, through teamwork and long-term planning, a five-year prescribed burn forecast for 20 burns was developed.

It is now possible to budget for the targeted burns and forecast stock requirements by year for each burning chance. We can be sure that the areas selected through team planning are excellent burning chances and will almost certainly be burned successfully.

The final result will be 20 candidate burns in the five-year prescribed burn forecast.

Teamwork

Above all, teamwork is essential if the burning plan and program are to be successful. Unit foresters must recognize the importance of site conditions in enhancing the fire manager's ability to conduct the burn with ease.

Fire managers must recognize that area targets are important and that areas must be prepared for the seedling stock that forest managers anticipate they will be planting.

Areas must be burned within reasonable, predetermined periods to meet those targets. The company forester must ensure that stands are cut and wood is removed so that ignition can proceed on schedule.

People in other disciplines will also become involved in the team planning process. For example, there could be negotiations with a biologist about creek and shoreline reservations. Detailed assessment of reservations usually results in the removal of some reservations and the protection of others. This type of site-specific planning will result in better utilization of all our resources. A multi-discipline team approach to prescribed burn planning will undoubtedly reduce burn costs and increase the area burned by prescription in the province of Ontario.

Site Selection and Team Planning in the Northern Region

Our past record for burning is outlined below.

	Total area (ha)	Total cost/ha
1982	3,820	$134.00
1983	4,682	$116.00
1984	3,664	$128.00

If we adopt a team approach using the five-year operating plan, I believe that we can expect the following results in the Northern Region:

1988	17,000 ha	$80.00/ha

With a team planning approach to site selection and pre-cut engineering to enhance prescribed fire treatment the following results should be realized:

1) larger areas treated by prescribed burning in the province of Ontario,

2) a drastic reduction in burning cost per hectare,

3) the chances of costly fire escape minimized,

4) fireproof prescribed burn boundaries permitting burning under higher burning indices and consequently making more burning days available,

5) areas pre-engineered for prescribed fire application reducing the pressure on the fire boss and making prescribed fire more acceptable across the province,

6) the chance of properly planned burns being completed increasing to nearly 100%.

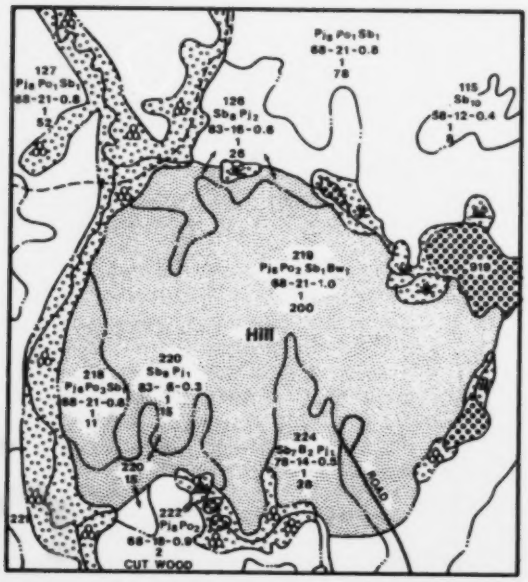
In summary, prescribed burning, on the average, costs less than heavy mechanical site treatment. The average burning cost in the Northern Region for the past three years is about $125.00/ha. By contrast, heavy mechanical treatment with D-8 tractors averaged about $225.00/ha.

On the basis of these figures, the Northern Region has burned 4,000 ha each year, and has saved OMNR about $1.2 million in site treatment costs over the past three years.

Tractor costs in the coming years will increase dramatically, whereas prescribed burn costs will likely decrease. Consequently, if we plan properly, select the right sites, and work as a team, we can achieve our goals efficiently and economically.

APPENDIX

ESTIMATING THE COST OF PRESCRIBED BURNS



PB No. 16 Musgrove Twp 250 ha

Basic starting cost/ha	$120/ha

Site Selection Factors

Natural boundaries: good boundaries, three sides	- $30/ha
Size: good 250 ha	- $20/ha
Shape: good circular	- $10/ha
Topography: excellent hill to center	- $15/ha
Access: fair to poor	+ $15/ha
Fuel complex: good 70% conifer	- $10/ha
Adjacent values: cut wood south	+ $15/ha
Difference from basic cost	- $55/ha
Estimated burning cost of Musgrove PB No. 16	$65/ha

PRESCRIBED BURNING AT OJIBWAY PRAIRIE PROVINCIAL NATURE RESERVE

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Wheatley Provincial Park and Ojibway Prairie Provincial Nature Reserve
Ontario Ministry of Natural Resources
Wheatley, Ontario

and

F. Bruin, Senior Fire Technician
Algonquin Region
Ontario Ministry of Natural Resources
Owen Sound, Ontario

Abstract.--The significance of the Ojibway Prairie was not widely recognized until the early 1970s. At 90 ha it is the largest protected tall grass prairie in Canada and is of international importance. It contains over 530 species, 95 of which are rare in Ontario. The principal management objective for Ojibway Prairie, the rehabilitation and restoration of the tall grass prairie ecosystem, calls for prescribed burns to arrest the invasion of woody plants and promote growth and plant diversity of prairie species.

Résumé.--Ce n'est qu'au début des années 1970 qu'on a largement reconnu l'importance de la prairie d'Ojibway. Ses 90 ha en font la plus vaste des prairies protégées à hautes herbes au Canada et lui confèrent une importance internationale. Elle héberge plus de 530 espèces, dont 95 sont rares en Ontario. Le principal objectif de l'aménagement de cette prairie, la remise en état et la restauration de l'écosystème de prairie à hautes herbes, réclame le brûlage dirigé pour arrêter l'invasion des plantes ligneuses et favoriser la croissance et la diversité des espèces de prairie.

Introduction

One of the very few areas in southern Ontario where tall grass prairie species still dominate the landscape is found within the boundaries of the city of Windsor in Essex County. The Ojibway Prairie Provincial Nature Reserve was established to protect this internationally significant ecosystem (Fig. 1 and 2).

Although the vegetation of the region is considered to be within the Eastern Deciduous Forest Biome (Rowe 1972), this prairie remains in spite of urban and agricultural developments that have reduced the forest cover in Essex County to about 2% of the total area. The prairie is on the eastern edge of the central great plains that once occupied a wedge-shaped area from Canada to Texas and from Iowa and Missouri to Ohio and Michigan (Langendoen

Figure 1. Location of Ojibway Park Provincial Nature Reserve.

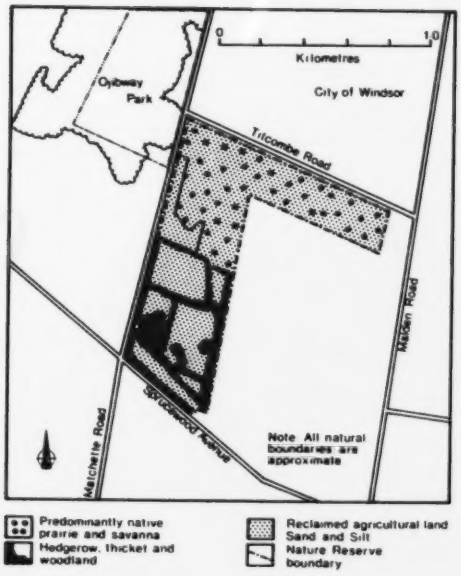

Figure 2. Enlargement of area near Windsor, Ontario showing boundaries of Ojibway Park Provincial Nature Reserve.

1983). In the early 1970s, concerned scientists such as Dr. P.F. Maycock and Dr. C.M. Rogers reidentified the significance of this tall grass prairie remnant and brought it to the attention of the Ontario Department of Lands and Forests, now the Ontario Ministry of Natural Resources (OMNR).

In 1971, the Ontario Department of Lands and Forests, The Nature Conservancy of Canada and the city of Windsor each contributed funds for the initial acquisition of prairie lands. In 1976, 65 ha were placed in regulation under the Provincial Parks Act to preserve this unique community of plants and their ecosystem. The nature reserve is owned and managed by OMNR. To date, 85 ha have been purchased at a cost of over $767,000.00 (approximately $9,000.00/ha) and a further 60 ha have been identified for a future acquisition.

In 1975, a master planning process was initiated and a proposed master plan was produced. Life and earth science research was undertaken, and in 1979 a life science report was completed (Pratt 1979).

Other research activities included the following:

1) A ground water study of the Ojibway Prairie (R.S. Guiton 1978)

2) The influence of fire at Ojibway Prairie Provincial Nature Reserve (G. Donaldson 1979)

3) Rare vascular plants of 12 provincial parks (K. Lindsay 1982)

4) Salt mine report (A.G. Tracey 1972)

5) Resource management options and considerations (R. Klinkenburg 1982)

6) Resource management plan for Ojibway Prairie Provincial Nature Reserve, November 1982 - October 1985 (P.A. Woodliffe and J.W. Sulston 1982)

7) 1983 burn plan for Ojibway Prairie Provincial Nature Reserve (F. Bruin and J.W. Sulston 1983)

8) The Windsor prairies--a study of vegetational and environmental features using detrended correspondence analysis (D. Langendoen 1983)

9) Insect survey of southern Ontario (D. Bright 1982)

10) Habitat use of individuals and populations of *Peromyscus leucopus* (white-footed mouse) and *Microtus pennsylvanicus* (meadow vole) during periods of high and low rodent density (J.A.L. Wilson 1983).

The importance of these studies can be appreciated when one considers the complexity of the tall grass prairie ecosystem.

History

Ten thousand years ago, southern Ontario was recovering from the last great glaciation. As the ice receded, climates tended to become warmer. At one point, about 5,000 years ago, a hot, dry period called the hypsothermal period (Kapp and Means 1977) allowed an easterly extension of the western prairie. These invasions took place in Michigan, Ohio, Indiana and parts of Ontario. A later cooling in climate destroyed most of the tall grass prairies in Ontario except for small pockets, such as at Ojibway Prairie (Bevan 1977).

The existence of the prairie can be accounted for primarily by one ecological phenomenon--fire. The prairie fire would burn off the prairie grasses but leave the roots intact and destroy tree seedlings to halt the natural succession from prairie to wooded

areas. But farmers soon discovered that the fertile prairie soil that once supported 30 million buffalo as well as other grazers could also support intensive agriculture if there was sufficient drainage, and as a result, prairie land fell to the plow.

The factors that probably saved Ojibway from intensive agriculture were its high water table, poor drainage, and the unscheduled periodic fires of unknown origin.

Significance of Ojibway Prairie Provincial Nature Reserve

The biological significance of the Ojibway tract was recognized by John Macoun, who visited the area in 1892. Macoun was impressed by the "eastern extension of prairie flora" (Macoun 1893).

Today, 90% or 113 of the 124 prairie species found in southern Ontario are found in the Ojibway area (Pratt 1979). Of the total 533 plant species, 95 are considered rare. Rarities include wild lupine *(Lupinus perennis)*, great plains ladies' tresses *(Spiranthes magnicamporum)*, prairie white fringed orchid *(Habenaria leucophaea)*, lily leaved tway blade *(Liparis lilifolia)*, and grey headed (or yellow) cone flower *(Ratibida pinnata)*.

Management

The Ojibway Prairie was described (Pratt 1974) as containing several different plant communities (Fig. 3) including the following:

tall grass prairie - open area covered with low-growing plants dominated by grasses and having fewer than 2.4 trees per ha

forb prairie - lands dominated by native forbs, with at least two of the leading dominants prevalent and/or modal for Wisconsin prairies as defined by Curtis (1959)

oak savanna - prairie species but more than 2.4 trees per ha

forests - including pin oak *(Quercus palustris* Muenchh.) forest, black oak *(Q. velutina* Lam.) forest, thickets and unclassified forest, and black oak-pin oak forests

recently abandoned fields - lands used as cropland within the last 5 years

old fields - lands abandoned for more than 5 years with at least two of the five dominant species being native species.

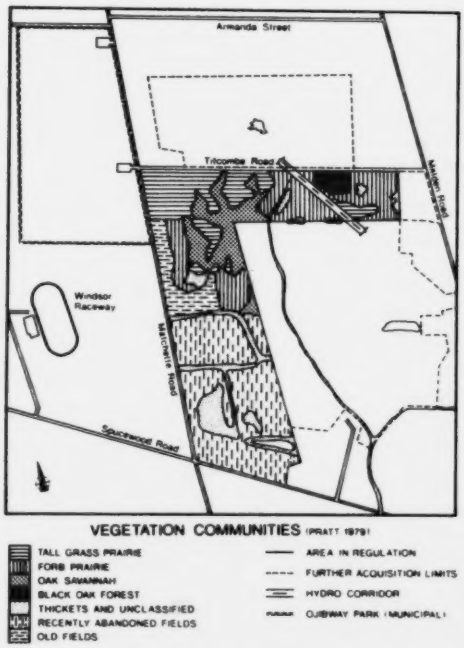

Figure 3. Ojibway Prairie Provincial Nature Reserve: existing vegetation communities.

For the purpose of management prescriptions, the resource management plan of 1982 would later identify only three communities - tall grass prairie, oak-savanna, and black oak forest (Fig. 4).

History of Fire in Prairie Ecology

"The last twelve miles we travelled after sundown and by firelight over the prairie, it being on fire. This was the grandest scene I ever saw, the wind blew a gale all day, the grass was dry.... In high grass it sometimes burns 30 feet high if driven by fierce winds. By light of this fire, we could read fine print for ½ a mile or more."

These observations by Alfred Brunson, a Methodist circuit rider, were recorded in 1835 (Angle 1968). There is also an unconfirmed report of one prairie fire that swept across

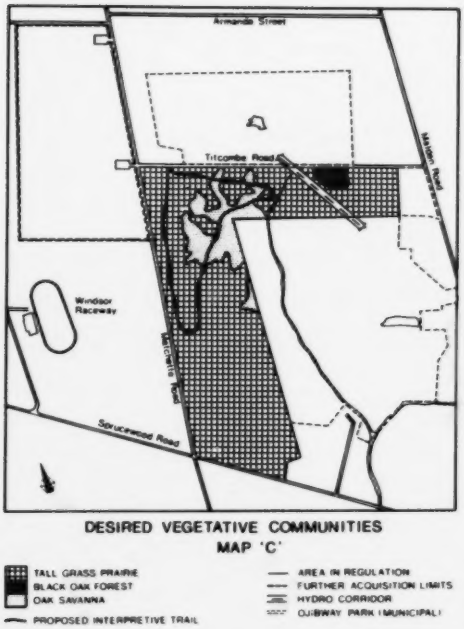

Figure 4. Ojibway Prairie Provincial Nature Reserve: desired vegetative communities.

five states. Prairie fires were caused naturally by lightning or were started by Indians to drive game, kill unwanted insects, make better pastures and facilitate travel.

Prescribed Burning

Prescribed burning of prairie grass was practically unheard of in Ontario until 1978 when a burn of 6 ha was carried out by OMNR at Ojibway Prairie. Since that time and up to 1983, many small fires of unknown or questionable origin have occurred in some areas of the prairies.

In 1979 OMNR hired Mr. Gregory Donaldson on contract to study the influence of fire in the Ojibway Prairie. Donaldson's study involved 13 plots with different fire and land-use histories. Biomass sampling involved collecting live and standing dead material from a 0.16-m^2 area in each quadrat. Dried weights were calculated after each sample had been oven-dried at 80°C for at least 40 hours. A short summary of Donaldson's 1979 study follows:

1) One plot (No. 32), which had undergone three major fires between 1975 and 1979, had the finest display of big blue stem *(Andropogon gerardi)* in the entire Ojibway complex. Litter accumulation was very low and yield of vegetative matter was the highest of that in all plots studied. There was a variety of other grasses and legumes, aster *(Aster* spp.) and goldenrod *(Solidago* spp.) and other composites. Woody growth was absent.

2) A second plot (No. 20) showed significant changes after the fire in the spring of 1979. In the control plot (no burn) the dry weight of live vegetation was slightly more than the accumulated litter, while in the burned plot, litter accumulation was 62 g in comparison with 273 g in the control plot. Dry weight of live vegetation in the burned plot exceeded that in the control plot by 54 g. Production of grasses, aster and goldenrod species was increased in the burned section.

3) Woody species, particularly poplars *(Populus* spp.), oaks *(Quercus* spp.), sumacs *(Rhus* spp.), dogwood *(Cornus* spp.) and grape *(Vitis* spp.), were actively advancing in all but the most frequently burned study plots and plots with recent agriculture.

Donaldson concluded that "all the communities sampled are jeopardized by the presence of quercus forest succession with pioneer stages of sumac, dogwood, poplar and ash *(Fraxinus* spp.)". A healthy and diverse eastern prairie would consist of blue stems, other grasses, legumes, asters, goldenrods, and other composites. At Ojibway, the prairie communities contained all of the above prairie plants, but the presence of trees and shrubs indicated the transition to a savanna community dominated by oak (Donaldson 1979).

Since the goal of the proposed master plan for Ojibway Prairie was "to ensure the protection and perpetuation of a unique example of tall grass prairie and prairie-savanna environment in Ontario," era management techniques[1] were recommended--specifically, prescribed burning.

Fire destroys the woody stem growth which, if uncontrolled, would lead to successional transition stages from savanna to wooded areas. Another reason for burning is to reduce the layer of litter, thereby increasing

[1] Era management techniques are physical operational techniques used to maintain the prairie ecosystem at a specific successional stage. They include prescribed burning, transplanting of prairie species, seeding, cultivation, mechanical harvesting, etc.

early-season soil warming and promoting plant growth. Later, spring burns set back the cool-season grasses that have already begun to grow, thereby giving the native grasses a growing advantage by reducing the competition.

At the University of Wisconsin arboretum in Madison, fire has been used as a management tool to maintain the prairies for over 30 years. Two prairies, the 26-ha Curtis Prairie and the 14-ha Henry Green Prairie, are small reminders of the 2.8 million ha of prairie that once covered Wisconsin. Oak forests originated with the cessation of the nearly annual fires (Muir 1965).

At the Curtis prairie, fire was used to control bluegrass and enhance prairie species. Since 1950, there has been a biennial burning schedule with one third of the prairie burned one year and the remaining prairie the following year. These fires resulted in increased frequency of dominant prairie grasses, big and little blue stems, Indian grass and prairie forbs such as goldenrods and grey headed cone flower, while Kentucky bluegrass (*Poa pratensis* L.) declined markedly.

A recent study examined the causal mechanism involved in increased productivity of the prairie following burning. Net radiation pattern, as well as soil temperature at the surface and 25 cm into the soil, were examined. The results showed that, during the spring, daytime temperatures were substantially warmer on the burned prairie than on the unburned. The blackened surface readily absorbed energy while the litter on the unburned prairie retarded soil warming since some radiant energy was reflected (Brown 1967). Total reproduction of above-ground biomass was 4,598 kg/ha on the unburned site in comparison with 9,326 kg/ha on the burned site. Brown concluded that the shoots on the burned area were exposed to temperatures favorable to photosynthesis during the day and at night the cooler temperatures near the ground reduced night-time respiration.

Brown's work was continued by Peet (1971). This study measured reflective air temperatures at 5 cm above the ground, leaf temperatures, and net primary productivity. The results showed that the burned prairie presented more favorable conditions during the spring. Also, litter surface reduced wind movement that could be a factor in leaf temperature during the early part of the growing season.

Leaf temperatures at mid-day were nearer the photosynthetic optimum, about 26°C, for big blue stem on the burned site than on the unburned site. This resulted in better early spring growth with 21.8 g/m^2 on the burned site and 0.6 g/m^2 on the unburned site (Peet 1971).

Effects of Burning at Ojibway Prairie

At the Ojibway Prairie between 1979 and 1982, the only fires were those of unknown origin. The fires were usually small, less than several hectares in size.

Work was being done, however, to pave the way for prescribed burning as a continuing management technique.

The immediate necessity for control of the invading woody plants was described in the life science report (Pratt 1979). Donaldson (1979) made note of the active advancement of woody species on all but the most frequently burned plots.

A flora and fauna update[2] again stated that the failure to institute a fire management program to date has resulted in a lowering of the overall quality of prairie, and cited intrusions of extensive clumps of young trees and thickets of dogwood, hazel and sumac.

Klinkenburg[3] states that "without burning, the areas are very rapidly being invaded by cottonwood (*Populus deltoides* Barto), oaks and ashes", and concludes that "a burning management program for the reserve is critical".

In the fall of 1982, a resource management plan for Ojibway Prairie was quickly produced and later approved by OMNR. With only a few exceptions the Canadian Botanical Association endorsed the document in its entirety.

This plan identified goals, objectives, resource management strategies and techniques, and implementation strategies for the period from 1982 to 1985. It also identified two areas of required work: physical removal of larger woody stems that would be unaffected by fire, and prescribed burning.

Coincidentally, the national economic situation spurred the federal and provincial governments to fund labor-intensive work programs in order to reduce the number of unemployed laborers.

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[2] Pratt, P.D. 1982. Flora and fauna update for Ojibway Prairie. Ont. Min. Nat. Resour., 8 p. (unpubl. rep.)

[3] Klinkenburg, R. 1982. Ojibway Prairie Provincial Nature Reserve--resource management options and considerations. Ont. Min. Nat. Resour., 18 p. (unpubl. rep.)

Under one such program, 22 workers spent 6 months clearing unwanted woody stems from the prairie. All the trees were removed by hand since no wheeled or other vehicles were used on the prairie because of the fragility of the prairie ecosystem soils.

By April 1983, 40 ha of prairie had been prepared for the upcoming prescribed burn.

1983 Prescribed Burn

In 1982, a prescribed burn plan was compiled. The first major burn of 40 ha was to take place in the spring of 1983.

A brief summary of the approved burn plan follows:

1) The goals and objectives of the burn, including a statement that fire in a tall grass prairie is an absolute necessity, were set out.

2) A fire organization chart identifying the fire boss, suppression boss, service boss, aerial observer, safety officer, plans and records officer, ignition boss and suppression staff, was drawn up.

3) Preburn considerations were identified:

   (a) Union Gas would be contacted about natural gas lines on right-of-ways.

   (b) Ontario Hydro would be contacted about a major hydro transmission corridor through the prairie. Phase-to-phase or phase-to-ground arcing was a possibility.

   (c) All wooden hydro poles would be protected by mowing a 5-m swath around them.

   (d) All wooden fence posts would have grass mowed around them.

   (e) All residences (approximately 50) in the immediate area would be visited on the morning of the burn.

   (f) Conservation officers would be on duty.

   (g) The Windsor Police Department would assist in traffic control.

   (h) The Windsor Fire Department would be on site.

   (i) The Canadian Forestry Service would have a research team on site.

   (j) The Ministry of Labor would have representatives on site.

   (k) News media representatives would be on site to record the fire.

   (l) A helicopter would be rented for aerial work.

   (m) The Windsor Raceway would be contacted.

   (n) Officials of the city of Windsor would be contacted (i.e., mayor, Parks and Recreation Department, Roads Department).

   (o) Emergency telephone numbers would be available (burn units, ambulance).

   (p) The Ontario Ministry of the Environment would be contacted.

   (q) The Windsor airport and Detroit airport would be contacted.

   (r) A weather station would be set up to record weather data (prior to and during burn).

   (s) A sprinkler system would be used to protect property outside the fire perimeter.

4) The environmental impact on air, soil and water courses was discussed, as well as the biological impact on fauna.

To achieve the desired results, the burn would be carried out under the following conditions:

	Minimum	Maximum
Fine Fuel Moisture Code (FFMC)	83	85
Initial Spread Index (ISI)	6	10
Temperature	12°	20°
Relative humidity	50%	60%
Winds	20 km/hr	30 km/h
Wind direction	WSW to W	WSW to W

The predicted rate of spread under these conditions would be 13.7 m/min to 19.8 m/min and the fire was expected to burn for 3 to 4 hours.

In April 1983 the prescribed burn was carried out. A research team from the Canadian Forestry Service in Sault Ste. Marie arrived on site to carry out fuel analysis and

record burn conditions. The preburn conditions were as follows[4]:

Preburn grass fuel loading	1.1 kg/m^2 (estimated) over entire site
Grass moisture content at 11.50 a.m.	4.7% oven-dry weight
L-layer (litter) moisture content at 11:50 a.m.	7.7% oven-dry weight
Small twig moisture content at 11:50 a.m.	17.7% oven-dry weight

Weather conditions on the day of the burn were as follows:

	0800 hr	1300 hr
Temperature	+10°C	+24°C
Relative humidity	36%	24%
Wind direction	SW	SW
Wind speed	2	12
24-hr precipitation total	0	0

[4] McRae, D.J. 1983. Memorandum on file, Wheatley Provincial Park.

The Fine Fuel Moisture Code (FFMC) on the day of the burn was 84 at 1300 hr.

The fire burned for about 4 hours with only several small jump fires occurring outside the burn area.

The results of monitoring by the Canadian Forestry Service are given in Table 1.

Table 1. Flame characteristics.

	Rate of spread (m/min)	Flame length (m)	Flame depth (m)
Head of fire	9.1	1	2.4
Back fire	0.8	0.3	0.2
Flank fires	1.2	0.4	0.3

Following the burn, data were recorded from eight plots located in the burn area; these data are summarized in Table 2.

Here it should be noted that the optimum head fire spread rate of 9.9 m/min is about 50% of that predicted by Van Wagner (1973). This may indicate that Van Wagner's figures need to be adjusted to Ontario conditions since the supplement is based on the Australian grass fire index[4].

Table 2. Fuel and fire behavior data sheet.

Ojibway Prairie Complex					
Plot No.	Fuel loading (kg/m^2)	Rate of spread (m/min)	Direction of spread (0°)	Frontal fire intensity (kw/m)	Time
1	1.657	1.6	357	678	14:30:43
2	1.507	3.6	345	1,388	14:05:19
3	1.761	2.4	343	1,081	13:17:26
4	0.464	4.6	60	546	13:10:22
5	0.798	9.9	343	2,022	12:19:35
6	0.526	5.7	345	767	14:02:07
7	1.177	-	-	-	14:42:28
8	0.843	8.1	276	1,747	14:16:17
Average	1.099	5.1	N/A	1433	

Monitoring

A monitoring program has been initiated to assess the response of vegetation to rehabilitative management procedures, specifically prescribed burning and physical control of undesirable woody species. Data collected from 1.0-m^2 quadrats within the plots will include identification and presence of species, and percentage cover of species. Two plots, named "shrub shrinkage plots", have been set up to assess the increase or decrease in size of shrubby areas on a linear scale.

The monitoring work is extremely important as it will determine the future resource management work necessary to maintain a healthy, diverse prairie.

Prescribed Burn 1984

A prescribed burn was scheduled for the spring of 1984; however, weather conditions were unsuitable and the burn was cancelled. The invasion of woody species could be termed "spectacular" since the 1983 burn. Some cottonwood suckers have grown over 3 m in one year.

As the resource management and monitoring programs are in the early stages, comparative data are not available, but the present data and visual observations indicate the necessity of annual prescribed burns in Ojibway for at least the next few years. As the invasion of woody species decreases to an acceptable level, prescribed burns may not be necessary every year.

Conclusion

From the foregoing one can conclude that fire has three very beneficial effects on the tall grass prairie:

1) Fire eliminates much of the excessive woody plant growth and cool-season non-prairie species.

2) Fire clears the ground of litter to allow for the increased soil temperature necessary to stimulate growth of prairie species.

3) Fire makes stored nutrients in dead vegetation available to new growth and allows for more luxuriant current-year growth.

There is no evidence in the literature that fire is anything but beneficial and necessary to maintain a healthy, diverse, tall grass prairie ecosystem. Over the years, other management techniques used successfully in restoring prairies in the United States have been recommended. These include cutting of prairie grass, mulching, baling of prairie hay to reduce litter, seed collection by machinery, seeding, transplanting, transplanting of prairie sod, use of herbicides to control woody growth, etc. In the Ojibway Prairie, however, only fire and physical removal of woody stems are being used at present as management precriptions.

Literature Cited

Angle, P. 1968. Prairie state: impressions of Illinois 1673-1967 by travellers and other observers. Univ. Chicago Press, Chicago, Ill. 62 p.

Bevan, L. 1977. The Windsor Prairie. Nat. Can. 6(3):9-12.

Brown, C.T. 1967. Growth and energy relationship on burned and unburned prairie in S. Wisconsin. Univ. Wisc. Press, Madison. 51 p.

Curtis, J.T. 1959. The vegetation of Wisconsin. Univ. Wisc. Press, Madison. 629 p.

Donaldson, G.R. 1979. The influence of fire at Ojibway Prairie Provincial Nature Reserve, Windsor, Ontario. Ont. Min. Nat. Resour. 34 p.

Kapp, R.O. and Means, T.P. 1977. Pollen analysis of peat from a sinkhole in Garden Peninsula, Delta County, Michigan. Mich. Bot. 16(2):55-62.

Langendoen, D. 1983. The Windsor Prairies: A study of vegetation and environmental features using detrended correspondence analysis. Univ. Toronto, Erindale Coll., Toronto, Ont. 27 p.

Macoun, J. 1893. Notes on the flora of the Niagara Peninsula and shores of Lake Erie. Hamilton Assoc. J. Proc. 9:78-86.

Muir, J. 1965. The story of my boyhood and youth. Univ. Wisc. Press, Madison. 227 p.

Peet, M.M. 1971. The effect of burning on microclimate and production in Wisconsin tall grass prairie. Univ. Wisc. Press, Madison. 125 p.

Pratt, P.D. 1979. A preliminary life science inventory of the Ojibway Prairie complex and surrounding area. City of Windsor Parks and Recr. Dep. and Ont. Min. Nat. Resour. 163 p.

Rowe, J.S. 1972. Forest regions of Canada. Dep. Environ., Can For. Serv., Ottawa, Ont. 172 p.

Van Wagner, C.E. 1973. Rough prediction of fire spread rates by fuel type. Dep. Environ., Can. For. Serv., Chalk River, Ont. Inf. Rep. PS-X-42.

SYMPOSIUM WRAPUP

SYMPOSIUM WRAPUP

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It's a privilege for me to be here, with many former colleagues, to renew acquaintances and to participate in this update of fire and natural resource management. I feel somewhat like the race horse Northern Dancer which, after winning races, was put out to pasture but is now called back for special services.

During the past three days of the symposium we have heard many papers, well presented, that dealt with several facets of the subject at hand. Rather than go back over all the points made in the presentations and documented in the papers, perhaps I can wrap up the session by sharing with you my impressions and thoughts as the program unfolded.

To set the stage for my comments, perhaps I should recall the reason, purpose and theme of this symposium. In other words: "Why did we come here?" I have outlined below our reasons for being here, and have gone on to summarize, in point form, each of the papers presented.

1. *Symposium theme:* Integrating fire considerations into natural resource management.

2. *Symposium purpose:* To provide an opportunity for fire managers, resource managers and administrators:
   - to listen and learn
   - to discuss and debate
   - to meet and mingle

3. *Symposium objective:* To stimulate the process of integration by enlightening and exposing participants to:
   - new projects and recent developments
   - changes in policy, plans and activities
   - problems, issues and concerns

4. *Hidden agenda:* A challenge to all of us to change:
   - our attitudes and thinking
   - our methods and approaches
   - our systems and processes

Opening Remarks: John Sloan, Deputy Minister of Natural Resources (OMNR), Government of Ontario

- a very good executive statement to OMNR staff and all interested parties
- an excellent overview of OMNR priorities, strategies and plans
- a clear signal and direction to managers
- It is unfortunate that key staff of OMNR's Program Planning Unit could not be in attendance since integration is one of their primary responsibilities.

Session One: Client Comments, Resource Perspectives (Jackson)
Synthesis of first day's presentations:

- Fire is not the enemy, it is a natural element that must be considered by all natural resource managers.
- It is refreshing to hear someone pay tribute to Ontario's forest fire management policy.
- Although new opportunites for integration are presented there is a problem of scope and scale, e.g., translating forest resources, wildlife and wilderness targets for a site, forest or region into fire objectives requires compromise.

Wildlife Policy and Effects of Fire on Wildlife (Roseborough/Euler)

- two strong endorsements for close and constant collaboration between habitat and fire specialists
- a warning to managers that strict fire exclusion can be as harmful to populations as extensive, severe burns; it's the changing mosaic that counts
- More information is needed on cost:benefit relationships where fire is the agent of habitat renewal.

Parks and Wilderness Parks Policy (Richards/Beechey)
Quetico Park Fire Management (Harjula)

- The Parks management system provides an excellent opportunity for integrating fire considerations and extracting fire management prescriptions.
- Quetico's well developed fire management plan provides an immediate opportunity for a

pilot project and also serves as a generic framework.
- Charlie Van Wagner asked a pertinent question of Parks. "Can Parks specify the forest cover that would be ideal at a distant point in time? When that is identified what part can fire play in moving from the current to the desired vegetation?"

Forests--Protection from and/or the Use of Fire, An Industry Perspective (Innes)

- Mike presented a candid assessment of forest fire management in Ontario. OMNR managers should be attentive to each point in his paper.
- a key statement I noted: "Forest management is impossible without fire management."
- I recall a spring fire school at Longlac Pulp and Paper in the late 1940s when the subject of industry's priorities with respect to fire protection was raised. The answer then--"it depends"--seems to hold true today as there are even more considerations to be weighed in any strategic or tactical decision.

An OMNR Viewpoint (Armson)

- a landmark presentation revealing a major change in thought and perspective for forest resources.
- Ken Armson has set out the long-term objectives and concerns of forest management and has highlighted the role that fire control and fire use must play in meeting management targets.
- Field foresters should be made aware of this viewpoint by the chief forester.

Evening Banquet: guest speaker, Art Briggs

- Art in his inimitable way has reminded all of us, with good humor, of some salient points to keep in mind, e.g.:
  - i) keep the public, municipalities, and native groups informed and involved for maximum cooperation and assistance;
  - ii) be realistic about organizational strengths and weaknesses of your unit or agency when faced with increased demands for services and/or with constraints on resources;
  - iii) be fully aware of your own role and responsibility in setting values, priorities or strategies.

Session Two: Meeting the Challenge (Elliott)
Synthesis of second and third days' presentations:

- Forest fire management is neither simple nor static.
- The breadth and depth of presentations reveal a wide scope of practical and scientific advances that will not only improve state-of-the-art fire technology but also bring an interdisciplinary approach to fire plans and operations.

History and the Natural Role of Fire in Ontario (Lynham)

- From Prometheus to yesterday's lightning storm Tim has outlined the history and role of fire, particularly in the boreal forest.
- The key point for resource managers is to consider the effects of fire on three temporal and spatial scales and to identify natural fire regimes.

The Realities of Managing Fire in Ontario (Goodman)

- This talk is clearly the focal point of the symposium, striking a balance between the demands of clients and the capacity of fire.
- Pragmatic portrayal of fire management in Ontario, covering the topic in terms of realities and focus.
- I strongly urge the dissemination of this address to all field fire stations. The troops need to know what the commander is thinking.

Determining Fire Priorities in the Northwestern Region (Kincaid/Gagnon)

- The speakers have taken the area planning concept and translated it into practical guidelines for a specific region.
- The two regions in which planning is now in place, the Northern and Northwestern, serve as patterns for others and models for the future. The message is simple: area planning works--do it.

Fire in Forest Operations (Bishop)

- Bob has highlighted the efforts and concerns of the forest industry. He has traced the pattern of relationship between government and industry with respect to fire.
- The pattern of ups and downs in this relationship suggests the need to stabilize them at the most effective level.
- Fire managers/woods operators need concrete links to ensure free and open discussion of mutual concerns.

Prevention of Forest Fires (Dasti)

- David suggests a new, enlightened examination of fire occurrence and prevention.

- His new philosopy is radical but worthy of further elaboration and development.

Fire/Harvesting and the Timber Supply (Van Wagner)

- Charlie's presentation reminds one of Star Wars: he has led us out to the frontier of fire economics.
- With his laser gun he has blasted away at traditional thinking, e.g., "area burned" and "cost plus loss," and guided us toward a new horizon where the impact of fire, both negative and positive, becomes simply a part of the total economic equation for the whole forest.

Measuring Forest Depletion by Fire (Woods/ Osborne)

- two papers on the same topic--effects of fire--but from two perspectives, a joint approach that is long overdue
- These two practitioners have developed a sure cure for AIDS, i.e., Acute Information Deficiency Syndrome.

Decision Analysis for Prescribed Burn Planning (Martell)

- In the same way that pumps and hoses were tools that revolutionized fire suppression, David's decision model is a tool that will revolutionize fire planning.
- The distinct advantage of this analysis process is its comprehensive nature and the fact that each venture provides new data for refining and improving future outputs.

Regeneration Success as a Measure of Site Preparation Effectiveness (McRae)

- Doug's scientific analysis and evaluation of case histories disclose indicators and trends that will serve as input to Martell's model and aid in developing prescribed burn guidelines.

Northern Region Prescribed Burn Program Costs, Benefits, Results (MacQuarrie)

- Close liaison, long-term planning and team work are key points in this region's approach. Murray's well documented example amply illustrates that fire is an alternative method of site preparation that cannot be ignored.
- This practical but thorough planning sounds similar to a multiple prescribed burn plan prepared by Ed Herrington for a blowdown area of 34,000 ha near Vermilion Bay in 1973.

Prescribed Burning in Prairie Grass (Bruin)

- If anyone had told me 10 years ago that a prescribed burn would be executed within the city limits of Windsor I would not have believed him.
- a refreshing example of the application of creativity, innovation, enthusiasm, and experience to solve a natural resource management problem.

General Comments and Summation

1. This symposium is sponsored by COJFRC. It has been well crafted and managed, giving all of us much food for thought and a challenge to the status quo.

2. There are two issues that might have been covered if time had permitted:

   (i) RESEARCH in the past has had much to do with the current level of fire management. Although specific projects were described or illustrated, a general report on fire research--its current activity, future outlook, strengths and weaknesses--would have brought everyone up to date.

   (ii) EDUCATION at all levels and in all specialties has also contributed significantly to the current level of expertise and professionalism. As the science of forest fire management advances and as integrated resource management becomes the norm it would be helpful to hear from the academic community about concerns and trends in the education and training of tomorrow's decision makers.

3. Another observation I might make concerns the limited and minor role of women in this symposium. Jack Godden of the United States Forest Service recently attended a similar meeting in the United States, and over half the delegates were women.

4. All COJFRC symposia involve a field trip and this one is no exception. Your field trip meant going into the room next door to see, hear and talk about many more activities than you could have visited by using the traditional mode of travel. Those responsible for setting up and manning the various exhibits have done an excellent job. I hope you have taken advantage of the opportunity to get first-hand exposure to these exhibits.

To conclude, let me pose some questions for reflection:

(a) Why did you come to this symposium?
(b) Did this symposium meet your expectations?
(c) Did you get your money's worth?
(d) How are you going to follow up?

My challenge to you is to take just one idea from all that you heard and saw here during these past few days and pursue it further, by reading, inquiring, investigating or even going so far as to implement it so as to bring about change.

[illegible]
IN THE FOREST FIRE MANAGEMENT SYSTEM

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